U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
PB80-131188

Technical Assistance in Developing Nonattainment Plans for Selected Areas in California

PEDCo-Environmental, Inc, Cincinnati, OH

Prepared for

Environmental Protection Agency, San Francisco, CA Region IX

Aug 79

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA-909/9-79-003

2.

3. R
PB80-131188

4. TITLE AND SUBTITLE
Technical Assistance In Developing Nonattainment
Plans For Selected Areas in California

5. REPORT DATE
August 1979

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
James A. Throgmorton

8. PERFORMING ORGANIZATION REPORT NO.
3280-I

9. PERFORMING ORGANIZATION NAME AND ADDRESS
PEDCo Environmental, Inc.
11499 Chester Road
Cincinnati, Ohio 45246

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.
68-02-2535
Task Order No. 9

12. SPONSORING AGENCY NAME AND ADDRESS
U.S. EPA, Region IX, Air Programs Branch
San Francisco, California 94105 and
California Air Resources Board
Sacramento, California 95812

13. TYPE OF REPORT AND PERIOD COVERED
Final

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Region IX Project Officer: Robert Baker
California ARB Project Officer: Michael Schieble

16. ABSTRACT

This report is intended to assist the California Air Resources Board by defining the nature, extent, and causes of violations of standards governing total suspended particulates in the air basins of the north coast, Sacramento Valley, San Joaquin Valley, and south central coast of the State and to identify the potential means of eliminating these violations.

The results of the study show that nonlocal, soil-related sources (i.e., natural background and regional sources) are the major cause of TSP in the studies areas. Secondary particulates are a primary contributor throughout the San Joaquin Valley, and crude oil steam generators in the southern part of this area appear to be the major source of much of the secondary aerosol. Some sites are strongly affected by local fugitive dust sources, which have a major impact on all but one of the special study sites. Primary particulate emissions from point sources are not significant at any of the sites except Fort Bragg. It was found that agricultural burning is not a major contributor to TSP at any of the sites, probably because of the excellent permit system already in operation.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Quality Standards	Non-Attainment	13B
Particles	Total Suspended Particulates	14G
Aerosols		7D
Dust	Fugitive Dust	11G

18. DISTRIBUTION STATEMENT Unlimited	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 438
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE A19-A01

EPA Form 2220-1 (9-73)

PB80-131188

TECHNICAL ASSISTANCE IN DEVELOPING NONATTAINMENT PLANS FOR SELECTED AREAS IN CALIFORNIA

August 1979

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Prepared for

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Contract No. 68-02-2535
Task Order No. 9
PN 3280-I

EPA Project Officer: Robert Baker
California ARB Project Officer: Michael Schieble

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

This report was furnished to the Environmental Protection Agency by PEDCo Environmental, Inc., Cincinnati, Ohio, in fulfillment of EPA Contract No. 68-02-2535, Task Order No. 9. This report has been reviewed by the Air Program Branch, Region IX, of the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute approval or endorsement for use.

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Region IX EPA 909/9-79-003

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ACKNOWLEDGMENT

This report was prepared for the U.S. Environmental Protection Agency, Region IX, and the California Air Resources Board in fulfillment of EPA Contract No. 68-02-2535, Task Order No. 9. Mr. James A. Throgmorton was the project manager and primary author. Statistical data presented in Section 3 were generated by Messrs. Robert Livingston, Steve Tomes, and Douglas Wylie. Mr. Philip Russell, of the Denver Research Institute's Materials Analysis Division generated the basic microscopy data which is presented in Section 4. That data was subsequently analyzed and interpreted by PEDCo Environmental. Chemical data in Section 5 were produced by PEDCo Environmental under the supervision of Mr. Craig Caldwell. A second subcontractor, Monsanto Research Corporation, produced the elemental data given in Section 5. This work was supervised by Mr. Neal Hodgson of Monsanto. Messrs. Nicholas Sharp, Robert Zimmer, and Joseph Carvitti performed the field microinventories discussed in Section 6. The review of reasonably available control measures (Section 8) was prepared by Mr. John Zoller. The author gratefully acknowledges the contributions of each of these persons.

Messrs. Raymond Cyphers and Michael Schieble were the project officers for the U.S. Environmental Protection Agency and California Air Resources Board. Mr. Jerry Wiens was the principal contact with the Air Resources Board and deserves praise for his dedication and continuing interest in this study.

EXECUTIVE SUMMARY

This study was primarily commissioned to interpret existing data (or hi vol filter contents) in such a manner as to define the origin of total suspended particulate (TSP) violations in terms of source type (i.e., natural background, fugitive dust, secondary aerosols, and directly emitted industrial particulates) within selected nonattainment areas. Of secondary interest were the identification of reasonably available measures for controlling particulate emissions from traditional sources and the design of additional studies which would define the TSP problem more precisely.

In order to accomplish these objectives, seven major tasks were undertaken: comprehensive statistical analysis of trends and patterns in historical TSP data; analysis of selected hi vol filters with scanning electron microscopy; analysis of a different set of selected hi vol filters for 17 elements (using X-ray fluorescence) and for $SO_4^=$ (using $Ba/SO_4^=$ turbidimetry); correlation and factor analysis of the resulting chemical/elemental data; microinventory of 22 sampling sites in the nonattainment areas, followed by application of an empirical particulate modeling technique; survey of regulations affecting emissions from traditional sources throughout the nation; and synthesis of the information provided by these techniques into an overall definition of the TSP problem in the studied areas.

Nonlocal, soil-related sources (i.e., natural background and regional sources) were found to be the major cause of concentrations observed in the studied areas. Secondary particulates were found to be significant contributing factors throughout the San Joaquin Valley. Crude oil steam generators in the southern part of the San Joaquin Valley appeared to be the major source of much of the secondary aerosol measured in that part of the valley. Certain sites were found to be strongly affected by local fugitive dust sources, and all but one of the special study sites were found to be impacted to a significant extent by such sources. Primary particulate emissions from point sources were not found to have a significant role at any site except Fort Bragg. Agricultural burning was not found to be a major contributor at any site, most probably because of the excellent permit system currently in operation.

Numerous difficulties were, not unexpectedly, encountered during the course of the study. The major ones are that representative blank filters were not available for all of the loaded filters analyzed with X-ray fluorescence, that the extraction method required to permit the microscopic analysis of filters caused an unknown fraction of that material to be lost, and that time constraints prohibited the microscopic analysis of all filters planned for analysis.

SECTION 1

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has adopted a set of national ambient air quality standards (NAAQS) that are designed to protect the public from adverse health and welfare effects. According to the Clean Air Act Amendments of 1977, those standards that relate to the public health (referred to as primary NAAQS) must be attained by not later than December 31, 1982 and maintained thereafter.* Secondary NAAQS must be attained within a reasonable period of time. The NAAQS for total suspended particulates (TSP) are given in Table 1-1.

Table 1-1. NATIONAL AMBIENT AIR QUALITY STANDARDS FOR TOTAL SUSPENDED PARTICULATES

Standard	Geometric mean concentration, $\mu g/m^3$	Averaging period
Primary	75	Annual
Primary	260	24-h, not to be exceeded more than once per year
Secondary	150	24-h, not to be exceeded more than once per year

The 1977 Amendments also indicate that states are required to submit state implementation plans for the attainment and maintenance of the NAAQS by January 1979 and to have EPA-approved plans by June 30, 1979. Where such plans are not approved by the date indicated, certain financial constraints may be imposed upon the affected states.

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* Primary NAAQS for carbon monoxide, ozone, and nitrogen dioxide must be attained by not later than December 31, 1987.

Total suspended particulate data recently generated by the California Air Resources Board (ARB) and local air pollution control districts within that state show that violations of the particulate standards are quite widespread. The resulting nonattainment areas are geographically extensive and primarily rural, thereby placing a significant burden upon the ARB in its effort to identify the causes of such widespread violations and to take the corrective action necessary to attain the standards by 1982.

The general purpose of this report is, therefore, simple and direct: to assist the ARB by defining the nature, extent, causes of, and potential means of eliminating TSP standards' violations in the following nonattainment areas:

Air basin	Nonattainment areas by county
North Coast	Mendocino
Sacramento Valley	Shasta, Tehama, Butte, Yuba, Sutter, Sacramento, Yolo, and Solano
San Joaquin Valley	San Joaquin, Stanislaus, Merced, Madera, Fresno, Tulare, Kings, and Kern
South Central Coast	San Luis Obispo and Salinas Valley

The funding necessary to provide such assistance was contributed by the Region IX office of EPA. According to the task order issued for that office, of primary interest is the interpretation of existing data (or hi vol filter contents) to permit the definition of the origin of TSP violations in terms of source type [i.e., natural background, fugitive dust, secondary aerosol (sulfates, nitrates, and organics), and directly emitted industrial particulate].[1]

Of secondary interest are the identification of reasonably available measures for controlling particulate emissions from traditional sources and the design of additional studies that are necessary to define the problem or individual source category contributions better. In response to the task order and in an effort to assist ARB, this report is divided into eight sections:

Section 2 - Study design for problem definition

Section 3 - Statistical analysis of historical TSP data

Section 4 - Microscopic analysis of historical hi vol filters

Section 5 - Chemical/elemental analysis of historical hi vol filters

Section 6 - Application of microinventory/empirical particulate model at selected sites

Section 7 - Definition of the TSP problem at representative sampling sites

Section 8 - Identification of reasonably available control measures

Section 9 - Design for additional studies

REFERENCES

1. Order under Basic Ordering Agreement. U.S. Environmental Protection Agency, Contracts Management Division, Research Triangle Park, North Carolina. Contract Number 68-02-2535, Task Order 9. September 27, 1978.

SECTION 2

STUDY DESIGN FOR PROBLEM DEFINITION

INTRODUCTION

The application of ambient particulate analysis and assessment methods to a large and geographically disperse set of data such as that found in California can be a complex and cumbersome task. For existing data, it is necessary to identify the specifically relevant data that are available, to identify and select appropriate data analysis techniques, to determine the data requirements of those techniques, to match the available data with each technique's data requirements, and then to determine the cost of analyzing the data with selected techniques and, where necessary, limit the types of analysis on the basis of cost restraints. For data that can be generated by new analysis of past hi vol filters, the task is further complicated by the need to determine what kind of data is desired and to determine how it will be generated.

This section presents the basic study design that the contractor followed during the course of the project. It is divided into six sections: a summary of available data analysis techniques, a summary of available data, a design for analyzing existing (ARB) data, a design for analyzing newly generated (PEDCo) data, a design for synthesizing the results of those analyses into a coherent whole, and a schedule for performing the work described. Where applicable, changes in the design that occurred during the course of the study are noted.

SUMMARY OF AVAILABLE DATA ANALYSIS TECHNIQUES

Numerous techniques exist for analyzing air quality data. Insofar as these techniques are amply discussed in a recent publication entitled Digest of Ambient Particulate Analysis and Assessment Methods, it is considered unnecessary to describe them in greater detail and it is assumed that the reader is familiar with this information.[1]

Table 2-1 presents a summary of the capabilities of each of the techniques discussed in the cited document. Review of this summary for those techniques that have the capability of defining

TABLE 2-1. SUMMARY OF TECHNIQUES

Technique (Section No.)	Task rankings			Resource requirements				Cost-effectiveness		
	Charac-terize aerosol	Identify source categor.	Quantify specific src. imp.	Man-power	Skill	Compu-ter	Data	Charac-terize aerosol	Identify source categor.	Quantify specific src. imp.
Long-term trends (2.1)	2	1	1	2	1	2	1	0.3	0.2	0.2
Seasonal patterns (2.2)	2	1	1	2	1	2	1	0.3	0.2	0.2
Daily patterns (2.3)	2	1	1	2	1	2	1	0.3	0.2	0.2
Diurnal variation (2.4)	2	2	1	4	1	1	2	0.3	0.3	0.1
Emission patterns (2.5)	1	2	2	4	1	1	2	0.1	0.3	0.3
Site classification (3.1)	3	2	1	4	1	2	1	0.4	0.3	0.1
Intersite correlation (3.2)	4	1	1	2	2	2	1	0.6	0.1	0.1
Pollution rose (3.3)	2	2	2	2	1	2	2	0.3	0.3	0.3
Upwind/downwind (3.4)	2	1	3	2	1	2	2	0.3	0.2	0.4
Correlation and regression (4.1)	1	2	1	6	3	3	2	0.1	0.1	0.1
Decision tree (4.2)	1	2	1	6	3	3	2	0.1	0.1	0.1
Precipitation (4.3)	1	2	1	2	1	2	2	0.1	0.3	0.1
Wind speed (4.4)	1	2	1	2	1	2	2	0.1	0.3	0.1
Trajectory analysis (4.5)	2	2	1	6	3	3	2	0.1	0.1	0.1
Emission inventory (5.1)	1	3	1	10	2	2	1	0.1	0.2	0.1
Microinventory (5.2)	1	4	1	6	2	1	1	0.1	0.4	0.1
Diffusion modeling (5.3)	4	4	5	4	4	3	1	0.3	0.3	0.4
Temporal, spatial, and meteorological (6.1)	4	2	2	2	2	2	5	0.4	0.2	0.2
Enrichment factor (6.2)	3	2	1	2	2	1	5	0.3	0.2	0.1
Chemical element balance (6.3)	2	4	1	4	5	3	5	0.1	0.2	0.1
Interspecies correlations (6.4)	4	2	1	4	3	2	5	0.3	0.1	0.1
Pattern recognition (6.5)	4	3	1	4	4	3	5	0.3	0.2	0.1
Factor analysis (6.6)	4	3	1	6	5	3	5	0.2	0.2	0.2
Microscopy (6.7)	4	3	2	8	5	2	2	0.2	0.2	0.1
Frequency distribution (7.1)	3(4)	2	1(3)	2(4)	2(3)	1(3)	4	0.3	0.2(0.1)	0.1(0.2)
Species-specific (7.2)	5	4	1	4	2	2	5	0.4	0.3	0.1

Source: Digest of Ambient Particulate Analysis and Assessment Methods, 1978.

qualitatively or quantitatively the impact of emission sources or source categories on TSP concentrations reveals the following 12 techniques to be the most promising:

Group I
1. Diffusion model

Group II
2. Microinventory
3. Chemical element balance
4. Microscopy
5. Species-specific particle sizing

Group III
6. Emission versus air quality relationships
7. Pollution rose
8. Upwind/downwind analysis
9. Emission inventory
10. Temporal, spatial, and meteorologically-affected chemical and elemental patterns (TSM techniques)
11. Pattern recognition
12. Factor analysis

These techniques vary in cost and complexity. Applying the summary resource requirement estimates shown in Table 2-1, it can be said that items 6, 7, and 8 are the least costly to implement, followed by a group comprised of items 1, 2, 5, and 10, and then by a group consisting of items 3, 4, 9, 11, and 12.

Table 2-2 summarizes the types of information that are required to use any of the 12 techniques.

SUMMARY OF AVAILABLE DATA

Table 2-3 summarizes the type and amount of data that the contractor expected (on the basis of information available at the start of the project) to be available for the sites that exceeded any of the primary or secondary particulate NAAQS during the period 1975 through 1977 (68 sites in 19 counties). Figures 2-1 and 2-2 show the location of the San Joaquin and Sacramento Valley sites. This initial review of data availability is quite important because the types of data available at any given site largely dictate the kinds of ambient particulate analysis techniques that can be applied. Certain of the California sites (as shown in Table 2-3) have not generated enough samples over the three-year period to make any kind of statistical analysis, other than a simple data summary, meaningful. Fifteen of the 68 sites have less than one year's data.

TABLE 2-2. DATA REQUIRED FOR SELECTED ANALYTICAL TECHNIQUES

Data requirement	Diffusion model	Microinventory/ empirical model	Chemical element balance	Microscopy	Species-specific particle size analysis	Emission/air quality patterns	Pollution rose	Upwind/downwind analysis	Emission inventory analysis	TSM technique (varies, depending on technique)	Pattern recognition	Factor analysis
TSP data for selected days			x		x			x		x	x	x
1 yr or more of TSP data	x	x										
3 yr or more of TSP data (each year well represented)						x	x					
7 yr or more of TSP data (valid AGM available for each year)						x[a]						
Sulfate, nitrate, and organic data for period of interest			x		x					x	x	x
Elemental data for period of interest			x		x					x	x	x
Ozone data for period of interest											x	x
LCD's for period of interest	x[b]						x[c]	x[c]			x	x
Representative wind rose	x[d]	x										
Upper air temperature data	x[e]										x	x
Rawinsonde data												
Point and area source emission data	x	x	x			x			x		f	f
Particle size data					x							
Traffic counts		x									g	g
Hi vol filters for lab analysis (unless data has already been generated)			x	x						x	x	x
Comments	**Not designed for rural areas**	**New data must be generated**	**Emission data may not be complete**	**New data must be generated**				**Samples must be fairly close together**				

[a] For long-term analyses.

[b] STAR program.

[c] Or daily wind data.

[d] Some models.

[e] Mixing height.

[f] Optimal.

[g] At least 20 days.

Source: Digest of Ambient Particulate Analysis and Assessment Methods, 1978.

TABLE 2-3. SUMMARY OF AVAILABLE DATA

Air basin/ County Site	No. of TSP samples[a]	Maximum AGM[a]	Maximum 24 h[a]	No. of secondary NAAQS violations[a]	>3 yr of TSP data available	>7 yr of TSP data available	$SO_4^=$, NO_3^-, organic data available[b]	O_3 data available	Elemental data available	Local climatological data available	Upper air temperature data available	Wind rose available	Point and area source emission data available	Particle size data available
North Coast														
Mendocino														
Capella	158	70	231	8	x	x							x	
Fort Bragg (S. Main)	155	110	455	30	x		x					x	x	
Ukiah	165	68	208	10	x								x	
Willits	172	71	211	7	x	x							x	
Sacramento Valley														
Shasta														
Anderson	127	70	250	6	x	x							x	
Tehama														
Corning	178	67	253	7	x								x	
Los Molinos	166	56	185	3	x								x	
Red Bluff	174	67	207	8	x	x							x	
Red Bluff (Lincoln)	152	63	178	4	x		x	x		x		x	x	
Red Bluff (Ag Comm)	176	55	193	2	x								x	
Butte														
Chico	174	80	187	5	x	x		x[d]			x	x	x	
Gridley	114	50	159	2									x	
Nord	141	46	238	3	x								x	
Yuba														
Marysville	168	59	164	3	x							x	x	
Wheatland	167	70	217	6	x								x	
Sutter														
Live Oak	149	110	242	19	x								x	
Pleasant Grove	145	65	263	11	x								x	
Sutter City	161	88	201	10	x								x	
Yuba City	35	-	170	3									x	
Sacramento														
Rancho Cordova	70	76	188	2									x	
Sacramento (Branch)	158	70	181	4	x								x	
Sacramento (P St)	175	69	155	2	x	x	x	x[d]		x		x	x	
Yolo														
Davis	69	67	192	2	x			x[e]					x	
Dunnigan	177	64	247	10	x								x	
W. Sacramento	194	73	192	7	x								x	
Woodland	131	75	277	6				x		x			x	
Solando														
Rio Vista (Main)	156	61	216	3									x	
Vacaville	119	62	234	2									x	
San Joaquin Valley														
San Joaquin														
Stockton	119	81	640	5	x	x		x		x		x	x	
Stanislaus														
Modesto (J St)	180	106	301	33	x			x					x	
Modesto (Oakdale)	157	89	234	13	x							x	x	
Patterson	119	78	206	5	x								x	
Salida	133	76	196	6	x			x[f]					x	
Turlock	142	89	236	10	x								x	

(continued)

TABLE 2-3 (continued).

Air basin/ County	Site	No. of TSP samples[a]	Maximum AGM[a]	Maximum 24-h[a]	No. of secondary NAAQS violations[a]	>3 yr of TSP data available	>7 yr of TSP data available	$SO_4^=$, NO_3^-, organic data available[b]	O_3 data available	Elemental data available	Local climatological data available	Upper air temperature data available	Wind rose available	Point and area source emission data available	Particle size data available
Merced															
	Los Banos	140	76	205	4	x			x			x	x	x	
	Merced	153	85	249	11	x			x			x	x	x	
	Merced (18&S)	150	96	293	20	x		x[d]	x			x	x	x	
Madera															
	Madera	75	91	249	15			x						x	
Fresno															
	Coalinga	126	88	243	18								x	x	
	Five Points	173	107	414	35	x	x		x[d]					x	
	Fresno (Cal State)	163	106	326	31	x					x	x	x	x	
	Fresno (Olive)	166	129	339	57	x		x	x					x	
	Parlier	167	133	422	62	x	x		x[d]					x	
Tulare															
	Goshen	172	150	480	92	x								x	
	Porterville	149	133	342	51	x								x	
	Porterville (S. Main)	20	-	231	10									x	
	Three Rivers	172	76	226	6	x			x[f]					x	
	Visalia	171	146	470	84	x	x		x				x	x	
Kings															
	Corcoran	32	-	405	35				x[g]					x	
	Hanford	58	-	427	33									x	
	Kettleman	46	-	403	23									x	
	Lemoore	41	-	279	13							x	x	x	
	Stratford	60	-	275	19									x	
Kern															
	Bakersfield (Chester)	190	155	416	83	x	x	x	x[d]				x	x	
	Bakersfield (Flower)	178	146	353	66	x	x				x		x	x	
	Bakersfield (6 other sites)	13-33	-	285-793	12-21								x	x	
	Kern City	14	-	278	12									x	
	Kern Refuge	114	84	390	21	x	x							x	
	Oildale		-	391	12									x	
	Taft (N 10th)	127	103	305	25	x			x				x	x	
South Central Coast															
Paso Robles		172	72	186	7	x		x	x				x	x	
Santa Maria (Library)		121	87	250	8		x		x				x	x	
Santa Ynez		27	113	258	7				x[h]					x	
Special Duty Data															
Bakersfield						x				x	x		x	x	x
Visallia										x			x	x	x

[a] Based on 1975-77.

[b] No data generated prior to spring 1976.

[c] 1975 missing.

[d] 1976-77.

[e] 1975-76.

[f] 1977.

[g] 1-1/2 years of data.

[h] 1975, 1977.

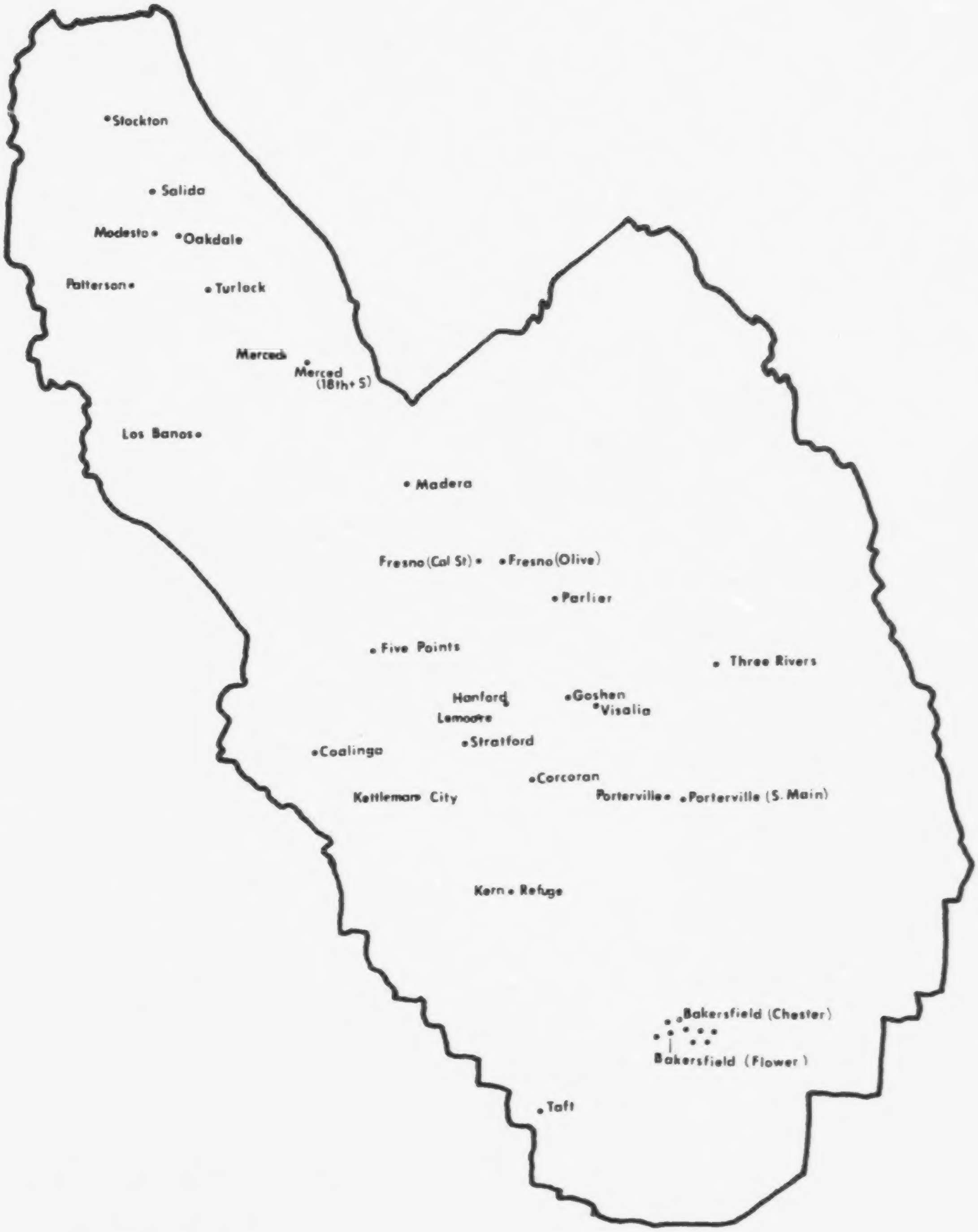

Stockton
Salida
Modesto
Oakdale
Patterson
Turlock
Merced
Merced (18th + S)
Los Banos
Madera
Fresno (Cal St)
Fresno (Olive)
Parlier
Five Points
Three Rivers
Hanford
Lemoore
Goshen
Visalia
Coalinga
Stratford
Corcoran
Kettleman City
Porterville
Porterville (S. Main)
Kern Refuge
Bakersfield (Chester)
Bakersfield (Flower)
Taft

Figure 2-1. Locations of San Joaquin Valley sites.

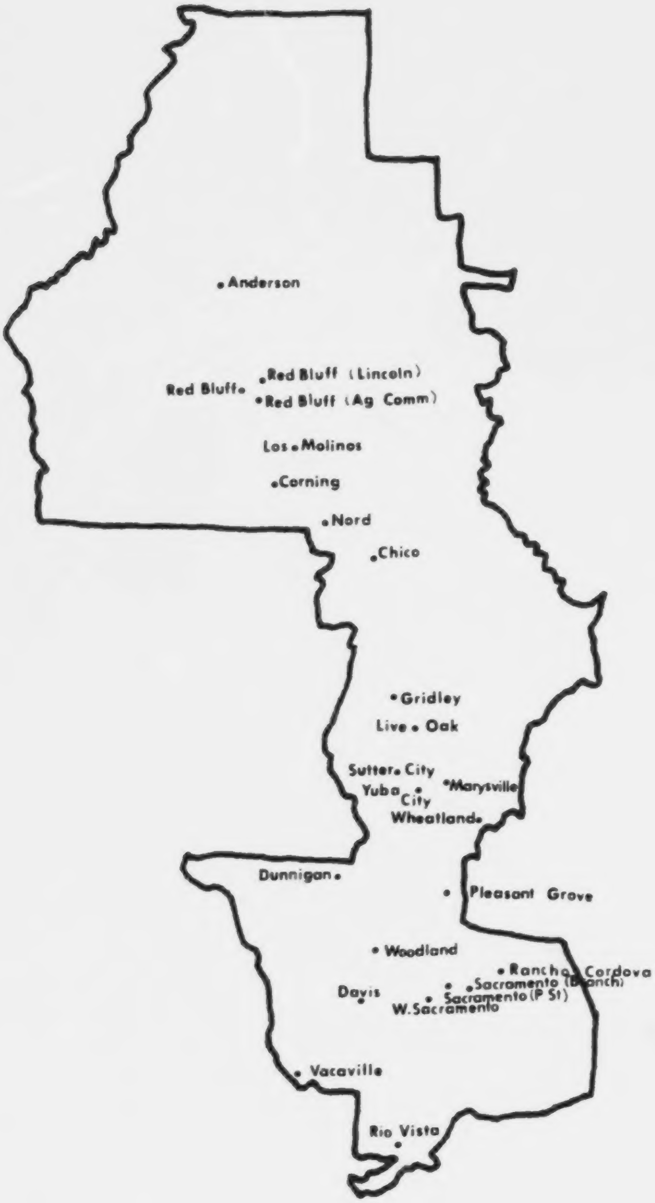

Anderson
Red Bluff
Red Bluff (Lincoln)
Red Bluff (Ag Comm)
Los Molinos
Corning
Nord
Chico
Gridley
Live Oak
Sutter City
Yuba City
Marysville
Wheatland
Dunnigan
Pleasant Grove
Woodland
Rancho Cordova
Sacramento (Branch)
Sacramento (P St)
Davis
W. Sacramento
Vacaville
Rio Vista

Figure 2-2. Locations of Sacramento Valley sites.

The magnitude of concentrations measured at the sites is also an important factor, for--given finite resources--attention should be focused on those sites that measure the most serious NAAQS violations. As Table 2-3 shows, there is great variation in the magnitude and frequency of NAAQS violations at the 68 sites. For the 68 sites listed, the annual geometric mean varied from 46 to 155 $\mu g/m^3$, the maximum 24-h concentration varied from 155 to 793 $\mu g/m^3$, and the number of excursions above the 24-h secondary NAAQS (1975-1977) varied from 2 to 92.

Violations may be either chronic or acute, stable or changing and the presence of either may be revealed by analyzing the long term trend of the TSP data. Unfortunately, only a few of the 68 sites had enough data (>7 years) to permit a statistically meaningful analysis of long-term trends in TSP concentrations.

The data summary in Table 2-3 basically indicates which sites can be analyzed for routine patterns and trends in TSP concentrations (e.g., quarterly means, daily means, long-term trends). Where more sophisticated analytical techniques (e.g., diffusion modeling, factor analysis, and trajectory analysis) are planned to be used, other data are necessary.

Substantial amounts (i.e., >1 year's data) of sulfate, nitrate, and benzene soluble organic data were available for 8 of the 68 sites, but only for the period from (at best) early 1976. At the start of the study, the contractor thought that the hi vol filters for these 8 sites had been completely consumed by the ARB's chemical analysis techniques and were not available for new elemental or microscopic analysis. That belief is apparently incorrect in some cases. None of the 68 sites generated either elemental (with the exception of lead) or particle size data.

Some size-fractionated elemental data were produced by Dr. Cahill of the Crocker Nuclear Laboratory at two locations in the 19 counties covered in the present project and by Dr. Elliott at Paso Robles. At one site (Bakersfield), data were available for the period mid-1973 to late-1977 whereas, at the other site (Visalia), data were available only for three months. Information concerning the Elliott data was obtained too late for substantial inclusion in the study design.

National Weather Service local climatological data (LCD) were thought to be available for 10 project cities. As the study progressed, the contractor found that such data were available only for Red Bluff, Sacramento, Stockton, Fresno, Bakersfield, and their environs. Upper air temperature data were available for only four cities but can be assumed to be representative of a much larger number of sites. Wind roses, some rather old, were available for 16 cities and can be considered to be representative of annual average conditions at 29 or more of the 68 sites.

Ozone data, potentially useful in factor analysis, were generated at 22 of the 68 sites and can be assumed to be representative of a somewhat larger set of sites. Ozone data generated by either the ultraviolet or chemiluminescent method were available for varying time periods at those sites, in most cases extending back to mid-1976.

Detailed emission data for both point and area sources were available for every county affected by this project; however, very little information was available concerning the elemental composition of emissions for specific point sources. Published data were available for such source categories as soil dust, sea salt, automobile exhaust, and crude oil.

DESIGN FOR ANALYZING EXISTING DATA

The design for analyzing existing data is necessarily a function of the interaction between the data requirements of promising analytical techniques, availability of data at sampling sites of intent, and relevance of the information that could be produced to the basic purpose of the project.

Of the 12 techniques previously listed as offering promise of providing source/receptor determinant information, 7 had to be discarded for various reasons. Diffusion modeling is primarily designed for application in urban areas where there is a large number of point sources and a diffuse array of area sources and where the intent is to define the contribution of individual sources. It is not really appropriate and certainly too costly for application in semirural and rural areas such as those found in the 19 California counties of interest.

The microinventory/empirical model technique is relevant but requires the generation of new data. Hence, it was not applicable to the analysis of existing data. Similar reasoning applied to the analysis of microscopy data.

The upwind/downwind technique is, generally speaking, most appropriate to situations where two or more samplers are located in close proximity to each other and where there is a suspected source located between them. This situation is not generally representative of the situation found in the counties of interest. Because the application of other techniques may suggest that an upwind/downwind analysis is appropriate, however, this technique was treated as a reasonable substitute for use where the situation warranted it.

Although the ARB has a large and sophisticated emission inventory, there were enough questions about the emission factors and allocation procedures themselves to warrant the exclusion of analyzing emission data as an appropriate technique.

The application of temporal/spatial/meteorological techniques for analyzing chemical/elemental data (see Reference 1) is dependent upon the availability of large amounts of such data. Since the only relevant existing data are those generated by Dr. Cahill at the Bakersfield and Visalia sites, it appeared that the application of these techniques was not warranted. The analysis of available data can be efficiently accomplished, however, through the use of factor analysis (see Reference 1 for a description of this technique). Pattern recognition was discarded because of its similarity to factor analysis and because factor analysis is a somewhat more powerful analytical tool.

Five of the original 12 techniques were thus retained. Emission pattern versus air quality patterns can determine whether TSP concentrations vary with known patterns of variations in emissions from different sources. This can be efficiently accomplished by looking at quarterly and daily means averaged over a three-year period and by looking at the trend in TSP concentrations over the past seven years. At the start of the project it appeared that there were 43 sites with ≧3 years' data and 8 sites with ≧7 years' data. These figures were found to change slightly during the course of the study.

The generation of a pollution rose can determine whether high TSP concentrations are associated with the direction of a known emission source. In order to assure that the rose is not biased by a small number of samples or by a transition involving the installation of emission controls, it is preferable to generate the pollution rose on the basis of two or three year's data. An additional requirement is that applicable wind data be available from those sites. There appeared to be 17 sites that met these criteria.

The generation of a set of size-stratified and species-specific roses can determine whether those species associated with a known type of source are associated with the known direction of that source type. Given the criteria described for the pollution rose and the need for species-specific data, only the Cahill data generated at the Bakersfield site were considered useful. Detailed analysis of the actual data, however, revealed that the Cahill data were too discontinuous to be interpreted in this manner.

A factor analysis of chemical, elemental, and meteorological data can be used to determine the percent of variance in TSP concentrations that is associated with empirically derived and source related factors. Again, only the data generated by Dr. Cahill could be usefully investigated with this technique. Because an important set of variables to include in the factor analysis is sulfate, nitrate, and organic concentrations and because such data are available at one other Bakersfield site only from the second quarter of 1976, the factor analysis was performed for Bakersfield data selected from the period between early 1976 and the end of the Cahill data (September 1977).

A chemical element balance can determine the percent that selected emission source categories contribute to measured TSP concentrations. Again, only the Cahill data were available for use with this technique. As the study progressed, it was concluded that it would be more fruitful to apply chemical element balances to newly generated data rather than to the Cahill data.

Two additional techniques were used: intersite TSP correlations and a linear regression of TSP concentrations against days since significant precipitation. The first technique, which was performed for the sites which have at least one year's data (53 sites), helped to determine whether certain sites vary together strongly, hence are affected by the same independent variable. The second technique helped to assess the relationship between high TSP concentrations and fugitive and windblown dust.

A matrix of the techniques which were applied to the 68 applicable sites according to this design is presented in Table 2-4.

DESIGN FOR ANALYZING NEWLY GENERATED DATA

There were many different types of data that could have been generated during the course of this project. Based upon the contractor's review of the literature, the ones that appeared to be most promising in terms of the objectives of the study were chemical data (i.e., sulfates, nitrates, and benzene soluble organics), elemental data (e.g., Ti, Al, Fe, Mg, Mn, K, Ca, Si, S, Ni, Zn, Pb, Br, V, Na, P, and Cl), microscopy data (whether produced by optical microscopy, scanning electron microscopy, or any of the other nascent miscroscopic techniques), and micro-inventory data. The following material describes the procedures that the contractor followed in generating new data of these types. Subsequently, there is a description of the techniques that were used to analyze the newly generated data, an indication of the number of filters that were analyzed, and a procedure that the contractor followed in selecting filters for analysis.

Generation of New Data

Microscopic Analysis--

This work was subcontracted to Denver Research Institute (DRI). A description of the scanning electron microscopy (SEM) procedures used by DRI is given in Section 4.

TABLE 2-4. TECHNIQUES APPLIED TO SPECIFIC SITES

Air basin/ County	Site	Quarterly and daily means	Long-term trends	Intersite correlations	Pollution rose	Days since rain	Factor analysis	Chemical element balance	Species-specific size-fractionated roses	Microinventory/ Empirical model	Microscopic analyses
North Coast											
Mendocino											
	Capella	x	x	x							
	Fort Bragg (S. Main)	x		x							
	Ukiah	x		x							
	Willits	x	x	x							
Sacramento Valley											
Shasta											
	Anderson	x		x							
Tehama											
	Corning	x		x							
	Los Molinos	x		x							
	Red Bluff	x		x							
	Red Bluff (Lincoln)	x		x							
	Red Bluff (Ag Comm)	x		x							
Butte											
	Chico	x	x	x		x					
	Gridley			x							
	Nord	x		x							
Yuba											
	Marysville	x		x							
	Wheatland	x		x							
Sutter											
	Live Oak	x		x							
	Pleasant Grove	x		x							
	Sutter City	x		x							
	Yuba City										
Sacramento											
	Rancho Cordova			x							
	Sacramento (Branch)	x		x		x					
	Sacramento (P St)	x	x	x							
Yolo											
	Davis	x		x							
	Dunnigan	x		x							
	W. Sacramento	x		x							
	Woodland			x							
Solano											
	Rio Vista (Main)			x							
	Vacaville			x							
San Joaquin Valley											
San Joaquin											
	Stockton	x	x	x							
Stanislaus											
	Modesto (J St)	x		x		x					
	Modesto (Oakdale)	x		x							
	Patterson	x		x							
	Salida	x		x							
	Turlock	x		x							

(continued)

TABLE 2-4 (continued).

Air basin/ County	Site	Quarterly and daily means	Long-term trends	Intersite correlations	Pollution rose	Days since rain	Factor analysis	Chemical element balance	Species-specific size-fractionated roses	Microinventory/ Empirical model	Microscopic analyses
Merced											
	Los Banos	x		x							
	Merced	x		x		x					
	Merced (18 and S)	x		x							
Madera											
	Madera			x							
Fresno											
	Coalinga			x							
	Five Points	x		x							
	Fresno (Cal State)	x		x		x					
	Fresno (Olive)	x		x							
	Parlier	x		x							
Tulare											
	Goshen	x		x							
	Porterville	x		x							
	Porterville (S. Main)										
	Three Rivers	x		x							
	Visalia	x	x	x							
Kings											
	Corcoran										
	Hanford										
	Kettleman City										
	Lemoore										
	Stratford										
Kern											
	Bakersfield (Chester)	x	x	x							
	Bakersfield (Flower)	x	x	x		x					
	Bakersfield (6 other sites)										
	Kern City										
	Kern Refuge	x	x	x							
	Oildale										
	Taft (N. 10th)	x		x							
South Central Coast											
Paso Robles		x		x							
Santa Maria (Library)				x							
Santa Ynez				x							
Special Study Data											
Bakersfield							x				
Visalia											

Elemental Analysis--

This work was subcontracted to Monsanto Research, Dayton, Ohio. A description of the X-ray fluorescence (XRF) procedures used by Monsanto is given in Section 5. For reasons that are discussed therein, Si, Na, and Ca were not investigated as originally planned.

Chemical Analysis--

The contractor performed this work in its own laboratory. Description of the procedures used are given in Section 5. For reasons discussed therein, NO_3^- and approximately one-half of the benzene soluble organic (BSO) analyses were not performed. Some total carbon analyses were performed after receipt of SEM data.

Microinventory--

The contractor performed field microinventories of selected California sites during November 1978 and February 1979. A description of the procedure used is given in Section 6.

Selection of Analytical Techniques

Four relatively new techniques were used in analyzing and interpreting the newly generated data: interspecies correlation analysis, factor analysis, chemical element balance, and empirical particulate modeling of the microinventory data. Microscopy data were interpreted directly by the subcontractor, then analyzed and interpreted by the contractor.

To be used most effectively, factor analysis should be performed in those situations where a wealth of data exists. Given the examples discussed in Reference 1, this task was initially interpreted to mean that the following data elements should be available:

- A minimum of 20 sampling days for each site so that the results could be assigned reasonably tight confidence limits
- TSP values for each day of interest
- Ti, Al, Fe, Ca, Mg, K, Si, Mn, Ni, Pb, Br, Cl, V, Zn, S, Na, P and source-specific elemental tracer concentrations for each data set
- $SO_4^=$, NO_3^-, and BSO concentrations for each data set
- Temperature, precipitation, barometric pressure, wind direction, wind speed, sky cover, visibility, and mixing height data for each data set
- O_3 data for each data set

Further, the need to generate elemental data for these sites required that hi vol filters be available.

The chemical element balance could be performed at any site for which chemical and elemental data have been generated and for which the major emission sources are identifiable. The empirical particulate model could be applied at any site for which at least one year's TSP and wind rose data are available and for which field microinventories have been conducted.

Individually, none of the above techniques will provide a complete answer to the basic question pursued by this project. To be most meaningful, these techniques should be applied as a group to selected sites. The results of each technique could then be used to cross-check and fill the gaps left by the others. This need to apply a variety of techniques and the costs associated with the various techniques imposed a ceiling on the number of specific sites that could be analyzed.

Recognizing the need for time to learn more about the specific data that were available and about the actual utility of any one technique as it could be applied to the California sites, the contractor decided to generate and analyze these data in two phases:

> Phase I - All four of the techniques described above were to be applied to eight sites: Bakersfield (Flower), Parlier, Fresno (Cal State), Merced, Modesto (J St), Woodland, Live Oak, and Chico.
>
> Phase II - Individual techniques were to be applied on a site-by-site basis depending upon the following:
>
> - Results of the analysis of existing data, especially the intersite correlations
> - Conclusions as to the accuracy and utility of the techniques used to generate and analyze new data, given the unique characteristics of the California sampling sites
> - Availability of the data necessary to apply the analytical technique

As the study progressed, it was concluded that Phase II would involve applying the four aforementioned techniques to six additional sites: Taft, Kern Refuge, Visalia, Five Points, Fort Bragg, and Paso Robles. In addition, the microinventory/empirical particulate modeling technique would be applied to eight other sites: Bakersfield (Chester), Kettleman City, Goshen, Fresno (Olive), Coalinga, Stockton, Sacramento (P St), and Red Bluff.

Sample Size for Phase I

The number of filters that can be analyzed for chemical or elemental constituents or looked at microscopically is largely a function of the cost of such analyses:

- Microscopy - \$240/filter
- Chemical ($SO_4^=$, NO_3^-, and BSO) - \$30/filter
- Elemental - \$40/filter for 210 filters
  \$33/filter for 400 filters
  \$25/filter for 500 filters
  (includes cost of preparing standards for 16 elements)

Figure 2-3 graphically illustrates the general relationship between analytical costs and the number of filters that can be investigated with each technique.

The number of filters that ideally should be analyzed is a function of the uses to which the data would be put. The contractor planned to use the chemical/elemental data to produce chemical element balances, interspecies correlations, and factor analyses for each of the eight sites identified. Figure 2-4 presents a graphical display of the statistical relationships among sample correlations, varying numbers of samples, and population (or true) correlations for a 95 percent confidence level. This figure implies that relatively large data sets are necessary to tighten the confidence limits surrounding chemical/elemental correlation statistics.

The statistical requirements do not play such an important role when it comes to microscopy. The number of samples that ideally should be analyzed is more qualitative than quantitative. It is best to analyze samples collected on days of high, average, and low TSP loadings. This implies a minimum of three samples per site.

Given the costs associated with filter analysis and the need for a reasonable degree of statistical confidence, it was decided that 24 filters would be analyzed for chemical/elemental constituents. This means that 192 filters and an additional 19 duplicate analyses for quality control would be analyzed during Phase I, and 144 filters plus 14 duplicate analyses would be analyzed during Phase II.

It was also planned that 6 filters per site would be analyzed microscopically. This would permit 2 filters to be drawn from each of the 3 filter loading ranges discussed previously and

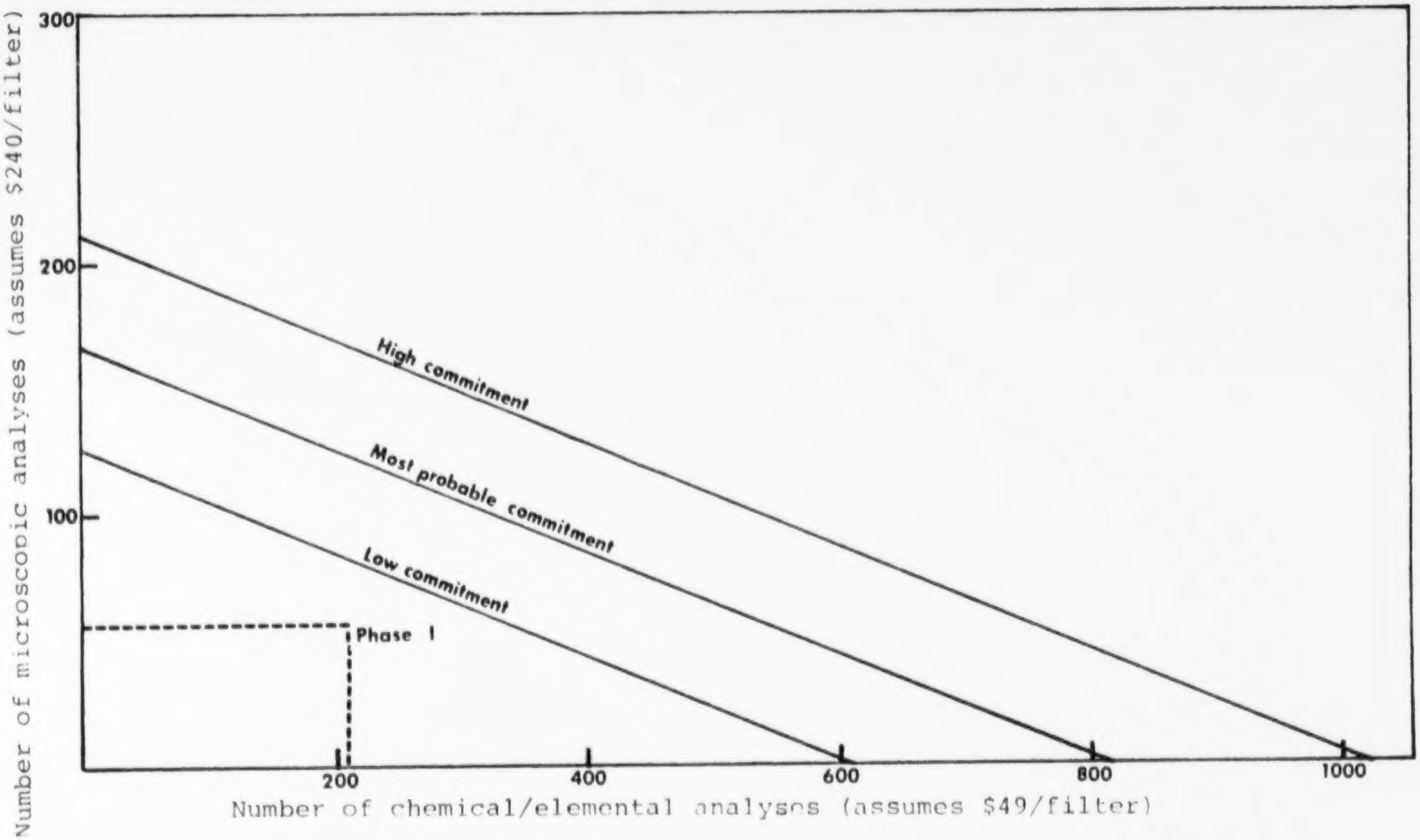
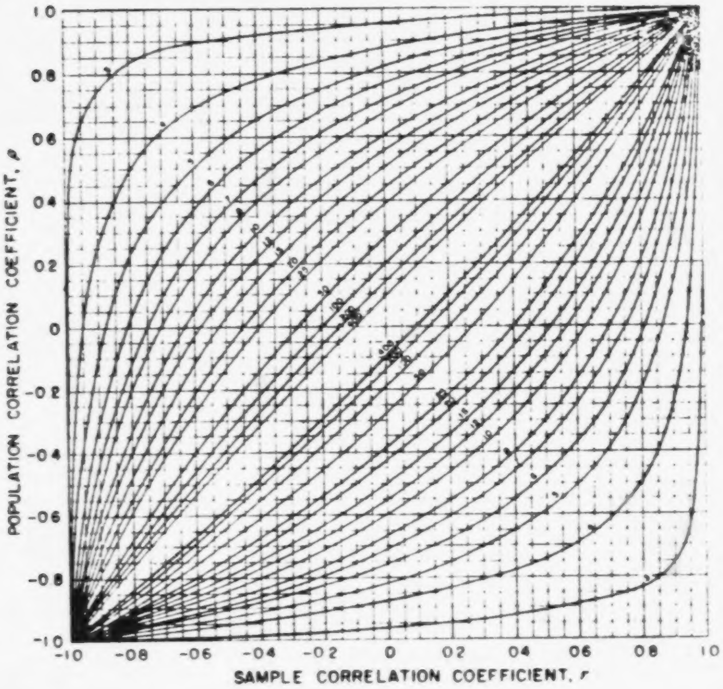


Figure 2-3. Interrelationships between cost restraints and the number of microscopic and chemical/elemental analyses.



The numbers on the curves indicate sample size for the case of a two-variable linear regression.

Figure 2-4. Ninety-five percent confidence belts for correlation coefficient.

Source: Digest of Ambient Particulate Analysis and Assessment Methods, 1978.

would increase the confidence in the meaningfulness of the results. Assuming an additional 10 percent would be analyzed in duplicate for quality control and that eight sites would be affected, this means that 56 filters would be analyzed microscopically during Phase I. After reviewing the Phase I results, it was concluded that Phase II should involve only the analysis of the 2 most heavily loaded filters from each site. Technical and administrative difficulties, however, forced DRI to cease its microscopic analyses shortly after it completed work on Phase I.

Selection of Filters for Analysis

The contractor intended to use the chemical/elemental statistics to make three determinations:

- What percent of variance in TSP concentrations was attributable to identifiable factors (based upon the three nonattainment designation years)
- The extent to which the variance attributable to these factors varies among the special study sites
- The percent that identifiable source categories contributed to average concentrations observed over the nonattainment designation period

These intentions implied a need to select filters at random over the 1975-1977 period. Because there may well be seasonal and yearly fluctuations in the severity of concentrations, the contractor decided to stratify the samples by quarter. Thus, 2 filters were to be selected at random from each of the 12 quarters during the three-year period.

This design was based on the assumption that blank filters representative of the lots from which loaded filters were drawn would be available. This assumption proved incorrect and necessitated a change in focus to the mid-1977 to mid-1978 period. Blank filters were generally, but not always, available for this period. Table 2-5 identifies the filters that were selected for analysis by this process.

TABLE 2-5. STRATIFIED RANDOM SAMPLE OF FILTERS

Year	Quarter	Filter sequence number[a]
1977	Third	1, 3, 7, 9, 11, 15
	Fourth	2, 4, 6, 10, 12, 15
1978	First	1, 5, 7, 11, 13, 15
	Second	3, 4, 6, 8, 12, 14

[a] The sequence number refers to the sequence of regularly scheduled sample days during that quarter.

The microscopic analyses were to be used to make a somewhat different set of determinations:

- The percent of total mass that is attributable to identifiable source categories
- The extent to which these contributions vary from days of high, average, and low loadings

Thus some of these filters should not be drawn at random. Rather, 2 filters should be from two of the highest days measured during the three-year period at each site. These 6 filters were to be a set of filters different from the 24 selected for chemical/elemental analysis and were to be drawn from the mid-1975 to mid-1978 period. Replacement filters were to be provided should there be any overlap between the two.

DESIGN FOR SYNTHESIZING RESULTS

In synthesizing the results of analyzing existing data, three basic guidelines were to be followed:

- Analyze data from the 14 special study sites (8 Phase I, 6 Phase II) in detail
- Use intersite correlations to assess the degree to which the other 54 sites are represented by the detailed information produced at the 14 special study sites
- Selectively apply other analytical techniques at the nonspecial study sites to investigate anomalies found after these two steps

Given these guidelines, the fundamental question was how the analytical results from the 14 special study sites could be synthesized to define the various source categories' percent contribution to TSP concentrations at those sites.

Figure 2-5 briefly illustrates the general approach that the contractor proposed to take toward this problem. Three intermediate types of synthesis were envisioned, all of which would aid in obtaining satisfactory answers to the questions addressed in this project:

- Synthesis by mass balance
- Synthesis by observing the differences between samples taken on high TSP days versus those taken on average TSP days
- Synthesis by comparing and resolving differences in conclusions generated by individual data analysis techniques

For each of the special study sites, the following determinations could be made with the data and analytical techniques discussed earlier:

- Whether TSP concentrations vary seasonally or by day of week in accord with the patterns shown by nearby emission source categories.
- Whether high TSP concentrations are associated with the direction of identifiable sources or source categories.
- Whether TSP concentrations vary strongly with a lack of rainfall (a surrogate for fugitive and naturally occurring windblown dust).
- Which factors (expected to be identified with known sources or source categories) explain the greatest percent variance in TSP concentrations.
- What percent of the average TSP concentration is associated with tracer-possessive source categories.
- What source categories are most strongly associated with high TSP days as compared with average or low days.
- The percent that extremely localized source categories contribute to average TSP concentrations and the percent of such concentrations that is attributable to background or unexplained phenomena.

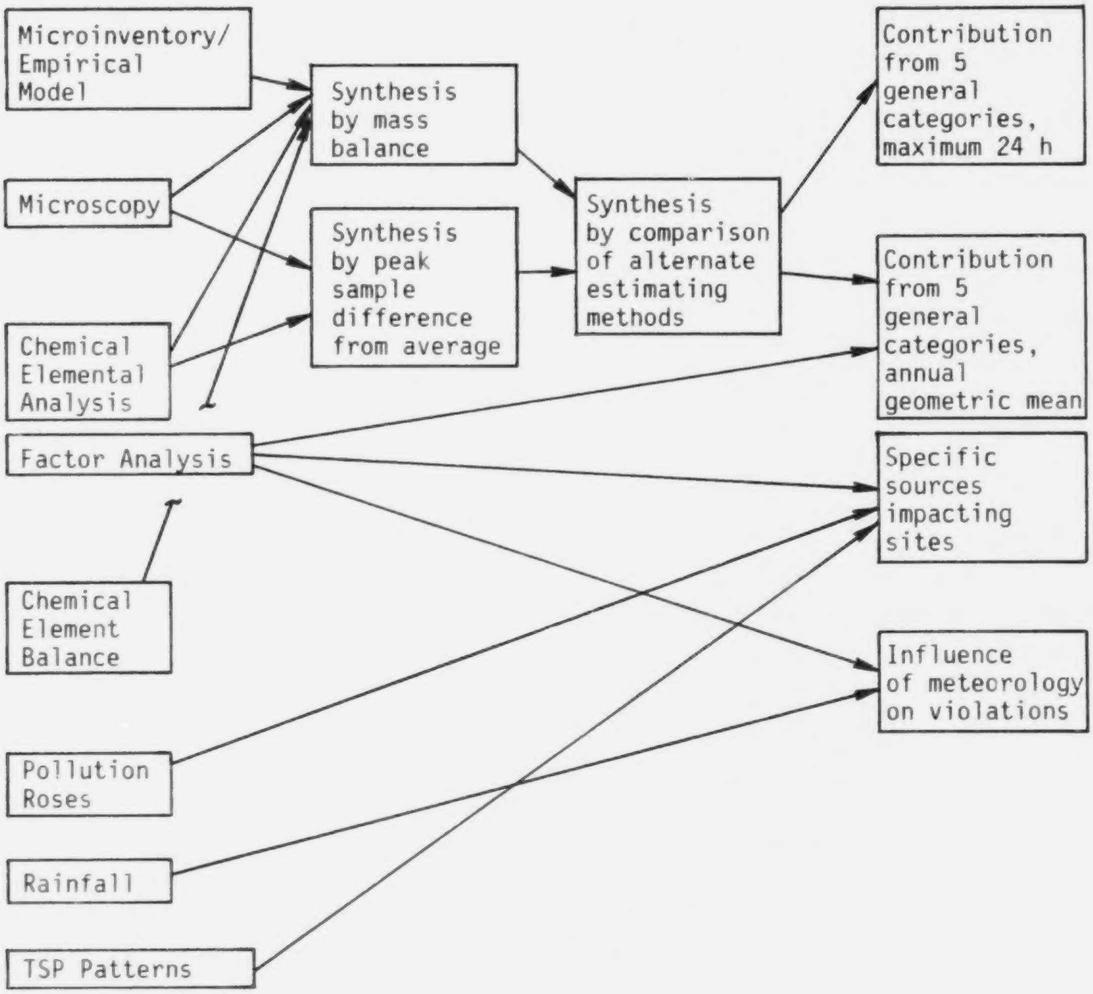

Microinventory/ Empirical Model
Microscopy
Chemical Elemental Analysis
Factor Analysis
Chemical Element Balance
Pollution Roses
Rainfall
TSP Patterns
Synthesis by mass balance
Synthesis by peak sample difference from average
Synthesis by comparison of alternate estimating methods
Contribution from 5 general categories, maximum 24 h
Contribution from 5 general categories, annual geometric mean
Specific sources impacting sites
Influence of meteorology on violations

Figure 2-5. Design for synthesizing results.

The data generated by the microscopy, microinventory/empirical model, chemical/elemental analyses, and chemical element balance would produce four different mass balances for each of the 14 sites investigated in detail. The mass balances would then have to be assessed in terms of the major source categories of interest.

Similarly, the data produced by microscopy and chemical/elemental analyses would produce information concerning the differences between concentrations measured on peak days versus those measured on average days for each of the 14 sites. These data would be assessed to determine source contributions during peak TSP conditions.

Other techniques, such as factor analysis and analyzing trends and patterns in TSP concentrations, would not contribute to the mass balances described but they could provide powerful means of qualitatively assessing the relative impacts of major sources, source categories, and meterological conditions.

SCHEDULE OF WORK TASKS

The entire project was scheduled to be initiated in October 1978 and completed by March 31, 1979. A detailed schedule for performing the tasks discussed in this section is given in Figure 2-6. Tasks related to defining reasonably available control measures were to be accomplished within the first month of the project and those related to designing additional studies were to be accomplished after the tasks discussed in this section were substantially complete.

REFERENCES

1. Digest of Ambient Particulate Analysis and Assessment Methods. PEDCo Environmental, Inc., Kansas City, Missouri. Prepared for U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. September 1978.

Work task	Schedule Oct	Nov	Dec	Jan	Feb	Mar	Effort[a] (man-hours equivalent)
Task B. Problem definition							
1. Study design	▬						200
2. Data acquisition							
Phase I							
Chemical, elemental, microscopic analysis for 8 sites		▬	▬				940
Microinventory for 8 sites		▬					80
Phase II							
Chemical, elemental, and microscopic analysis for 6 sites				▬	▬		660
Microinventory for selected sites		▬		▬			100
3. Data analysis							
Analysis of existing data from 68 sites		▬	▬				210[b]
Analysis of newly acquired chemical, elemental, microscopic, and microinventory data							
Phase I							
Chemical, elemental, microscopic		▬	▬	▬			120
Microinventory			▬				80
Phase II							
Chemical, elemental, microscopic					▬	▬	240
Microinventory				▬	▬	▬	380
4. Data synthesis							
Phase I				▬	▬		60
Phase II						▬	60
Effort (man-hours equivalent)	355	810	545	590	630	200	3130

[a] Assumes $25/h; the real rate will vary considerably depending upon the specific personnel involved.

[b] Plus computer time.

Figure 2-6. Schedule for tasks related to problem definition.

SECTION 3

STATISTICAL ANALYSIS OF HISTORICAL TSP DATA

INTRODUCTION

There were two objectives in mind when the statistical analyses reported herein were being designed and carried out. First was the desire to see whether available TSP concentrations were patterned in such a manner as to fingerprint major emission sources qualitatively. It was assumed that no one statistical technique would do this adequately so a variety of techniques were used. Second was the desire to see whether these patterns were associated with groups of sites and whether representative sites could be subsequently focused upon for further quantitative (e.g., microscopy) analysis.

Particulate data (1971 through 1978) from the 68 ARB sites listed in Table 2-1 were obtained from that agency on magnetic tapes and were analyzed in the following manner.

- Long-term trends - Two-year arithmetic sliding averages and monthly arithmetic averages were calculated for each of the 68 sites having at least six years of data.
- Regional grouping - The 68 sites were then grouped into five regions (coastal, northern and central Sacramento Valley, central and southern Sacramento Valley, northern and central San Joaquin Valley, and central and southern San Joaquin Valley) and the data sets for those sites were limited to the period July 1, 1975 through June 30, 1978.
- Temporal distribution criteria for analyses - The 68 sites were then screened to determine whether their data were adequately distributed throughout the three-year period of interest. The specific criteria applied were that there had to be a minimum of five samples per quarter continuously through the period and that if any one month in a given quarter produced no samples then each of the remaining two months in that quarter had to have produced at least two samples each. Twenty-six of the 68 sites met these criteria and were subjected to the remaining statistical analyses.

- Intersite correlations - Intersite correlation coefficients were computed for the sites within each of the five regions. Although the sites were grouped in such a manner as to achieve a degree of overlap between groups, there was no general effort to correlate all the sites with one another. It was felt that the resulting 2278 correlations would prove impossible to analyze productively. A second reason for grouping the sites relates to the nature of the correlation coefficient statistic. In order to compare the correlations among sites, it is necessary to ensure that those correlations are based upon the same data set. Thus, if any one site within a given region was missing data on a particular date, that data was withdrawn from the data set for all sites within the region. One-on-one intersite correlations were also computed for sites located within 50 miles of special study sites.

- Quarterly and day of week patterns - Three-year average quarterly and day of week patterns were computed for each of the 26 sites. The three-year time period was selected as a compromise between the need to factor out short-term fluctuations in meteorological conditions and the need to obtain enough data for each time period (e.g., Tuesday) to render the subsequent analysis statistically meaningful. Analyses of variance (ANOVA) were then performed on the three-year quarterly and day of week data. Similar patterns were also computed for special study sites that did not meet the inclusion criteria.

- Days of regionally high concentrations - Days of regionally high concentrations were analyzed by identifying the days when 50, 75, or 90 percent of the sites within a given region exceeded 150 $\mu g/m^3$ in the San Joaquin Valley or 100 $\mu g/m^3$ in the Sacramento Valley and subsequently determining the meteorological conditions present on those days. The fraction of the total number of a site's concentrations greater than 150 $\mu g/m^3$ that was attributable to such regional conditions was also determined.

- Pollution rose, wind, and days since rain analyses - Pollution roses, the effect of wind speed, and the effect of progressively drier soil conditions were also computed for four Phase I sites in the San Joaquin Valley.

LONG-TERM TRENDS

Sites with at least six years' data through the end of 1978 were evaluated in terms of changes in TSP concentrations over time. The intent was to determine whether any obvious changes had occurred and, if they had, to inspect emission-related data to see whether those changes could be attributed to any specific source or source category.

Thirteen sites were found to meet the criteria. Located geographically and assigned simple trend codes in Figure 3-1, these sites display unclear regional trends in TSP concentrations. A general trend toward increased concentrations may exist in the San Joaquin Valley but the data are not ample enough to arrive at that conclusion with any high degree of confidence. A general downward trend appears to exist in part of Mendocino County, but the number of sites giving this indication is quite small. Concentrations appear to be remaining essentially constant in the Sacramento Valley. But, again, this statement is based on a small number of sites and may not reflect the real valley-wide situation.

Figure 3-2 presents two-year sliding average arithmetic mean curves for 12 of the 13 sites. The thirteenth, Parlier, is presented in Figure 3-3. Capella and Willits, in Mendocino County, show clear--if slow--trends toward improving TSP concentrations. Significant improvements in concentrations at both sites began to occur in early 1976, indicating that some emission or meteorological variable changed significantly sometime in the first half of 1976.

Red Bluff, Chico, and Sacramento (P St) in the Sacramento Valley show no significant long-term trends, indicating that emission/meteorological variables have remained essentially stable near those three sites. Chico does show a slight increase in 1973 and 1974.

Santa Maria in Santa Barbara County demonstrates long-term stability, coupled with a significant but brief increase in 1976.

Stockton, at the northern end of the San Joaquin Valley, displays a significant and steady decrease in concentrations beginning sometime in late 1976. Five Points, Visalia, and Parlier--all in the center of the San Joaquin Valley--display somewhat different trends. Five Points' concentration is steadily increasing as is Parlier's. Both of these are rural, agricultural sites. Visalia, an urban site, shows no discernible trend but does reveal significant fluctuations over time. Since the meteorological/climatological conditions are quite similar at these three sites, the difference in observed trends can be attributed to differences in impacting emission sources.

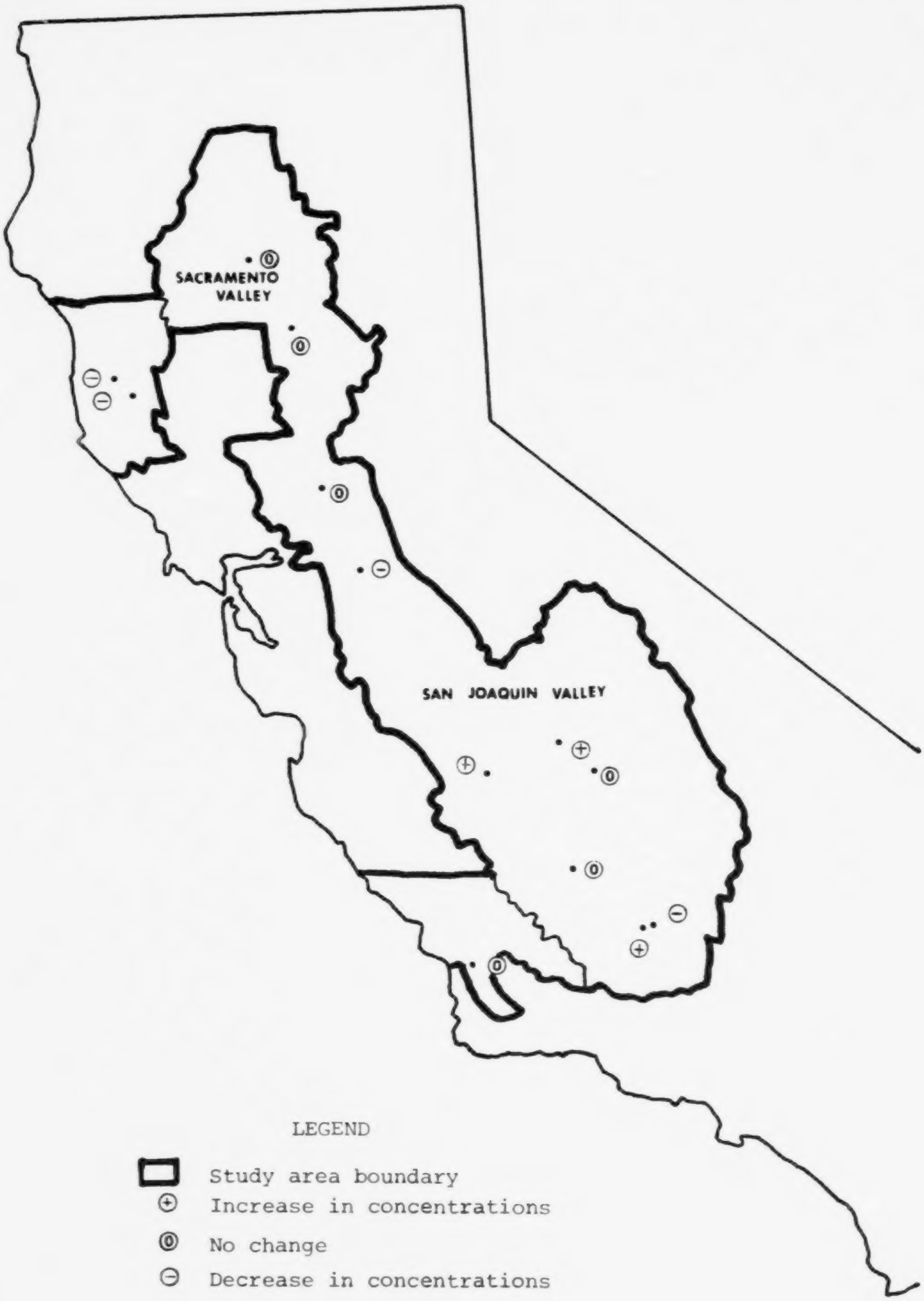

SACRAMENTO VALLEY
SAN JOAQUIN VALLEY
LEGEND
▭ Study area boundary
⊕ Increase in concentrations
◎ No change
⊖ Decrease in concentrations

Figure 3-1. Long-term trends in TSP concentrations, 1971-1978.

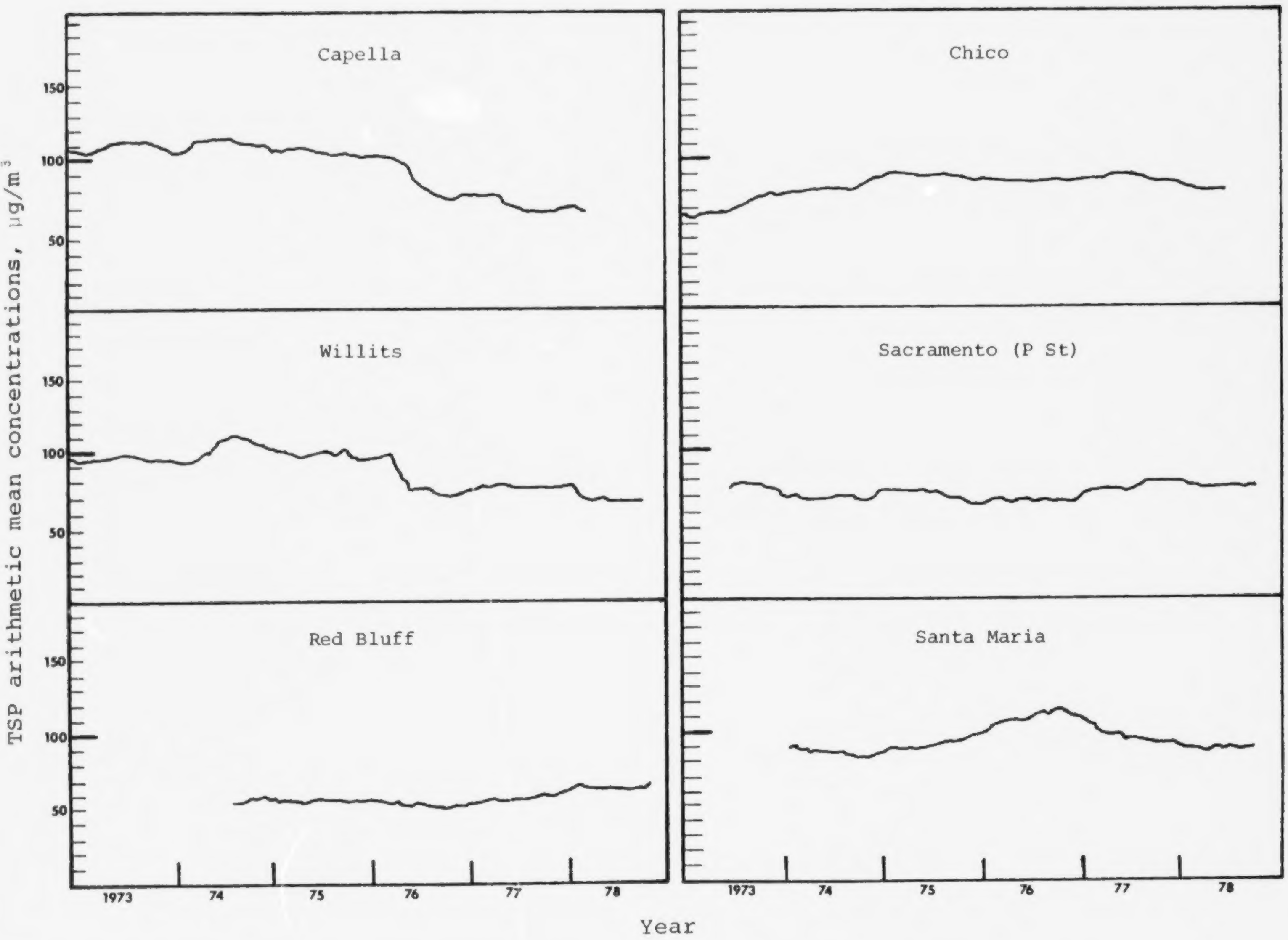


Figure 3-2. Long-term trends, two-year sliding arithmetic mean.

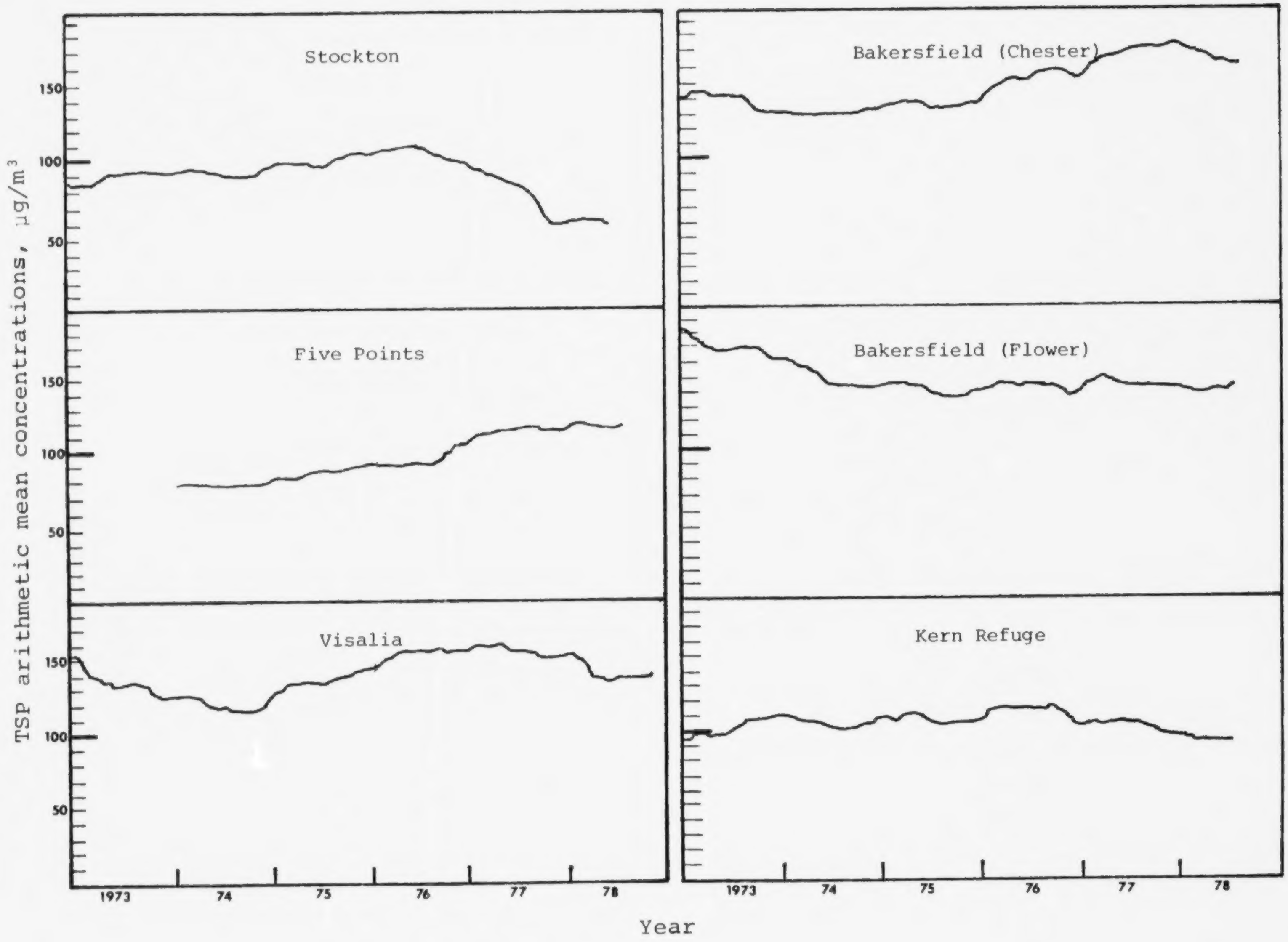


Figure 3-2 (continued).

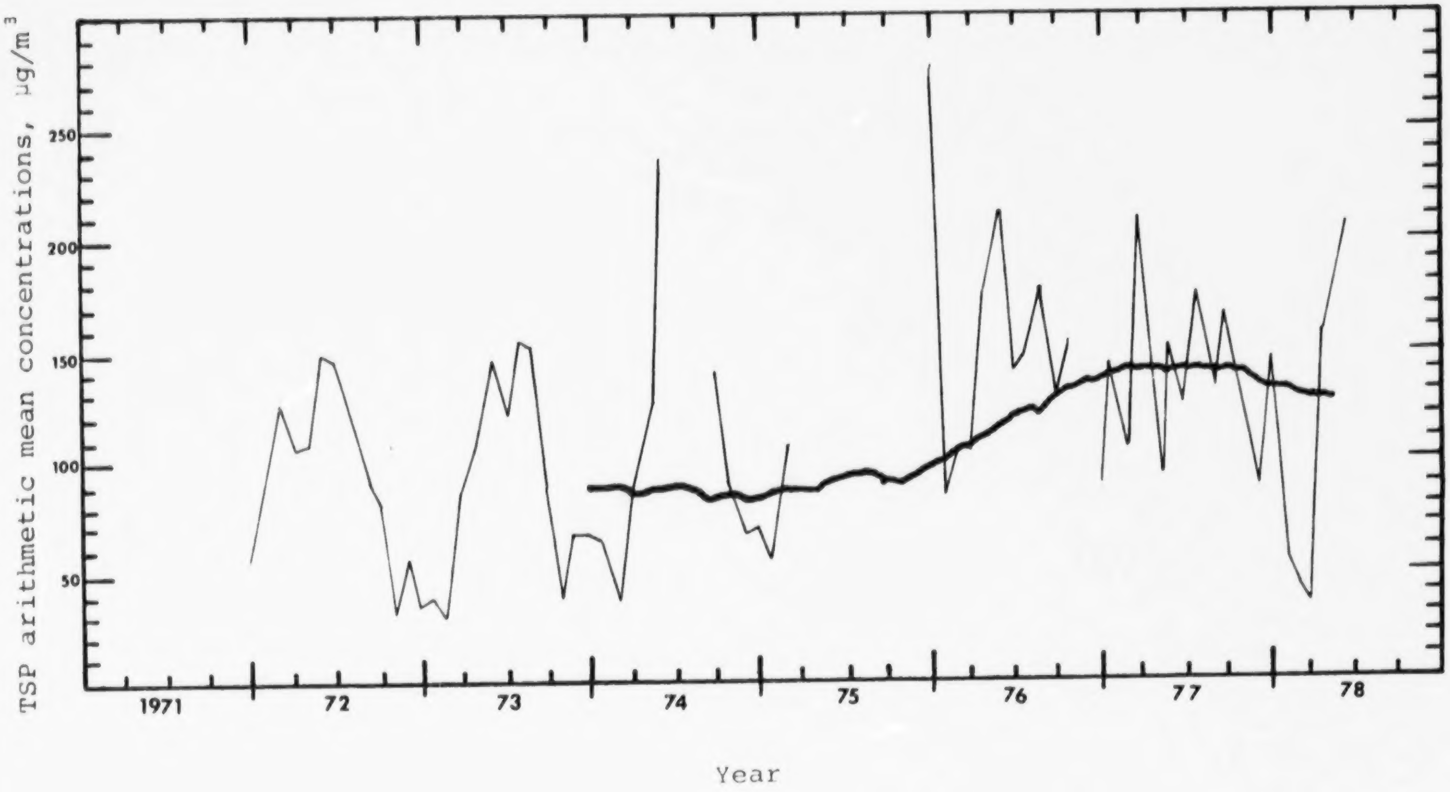


Figure 3-3. Two-year sliding arithmetic mean and monthly arithmetic mean, Parlier.

Trends at three sites in Kern County at the southern end of the valley are curious. There are two long-term trend sites in Bakersfield, Chester and Flower. The Flower site shows a significant decrease in concentrations in 1973 and 1974 (both in terms of its own trend and in comparison with the Chester site), whereas the Chester site shows a steady increase in concentrations (not observed at Flower) beginning in 1976. It can be concluded that some source near the Flower site came under control in 1973 and 1974 and that some source near the Chester site "began operation" around 1976. A nearby rural site, Kern Refuge, shows no discernible trend but does have significantly lower average concentrations ($\sim 50\ \mu g/m^3$ arithmetic mean) than the two Bakersfield sites.

When looked at in terms of the overall objective of this project, it must be concluded that this analysis of long-term trends has not helped to quantify the relative TSP contributions of major source categories; however, it has helped to implicate qualitatively certain sources/source categories at certain sites.

SEASONAL AND DAILY PATTERNS

Seasonal Patterns

A general description of the procedures applied to investigate these patterns was presented at the beginning of this section. It should also be noted that the first quarter consisted of January, February, and March; the second of April, May, and June; and so on.

Group I Sites--

This group represents coastal sites and nearby Sacramento or San Joaquin Valley sites. Four sites (Willits, Fort Bragg, Paso Robles, and Corning) met the inclusion criteria described previously. Data sets of 162, 149, 174, and 176 samples, respectively, were available.

As presented in Table 3-1 and shown in Figure 3-4, the data from these sites appear to be structured into three distinct patterns. Paso Robles and Willits show distinct fourth quarter maxima, Fort Bragg shows a distinct second quarter maximum, and Corning shows elevated third and fourth quarter values. The ANOVA conducted for these sites indicated that quarterly means differ from the three-year mean at the 95 percent confidence level for all four sites. In ANOVA, it is hypothesized that the variation in quarterly or day of week concentrations is not greater than the variation of concentrations over the entire three-year period. The validity of this hypothesis is assessed by applying the f-test. For selected confidence limits (e.g., 95 percent), the calculated f-value is compared to a predetermined

TABLE 3-1. QUARTERLY MEANS AND ANALYSIS OF VARIANCE FOR SELECTED SITES

Site	Total arith mean[a]	Quarterly arith mean[a,b] 1st	2nd	3rd	4th	Computed f-value	Probability of difference, %	Ratio of highest to lowest
GROUP 1								
Fort Bragg	101	93	124	90	99	3.230	95	1.38
Willits	69	75	62	55	86	6.940	99	1.56
Paso Robles	79	73	65	71	108	12.219	99	1.66
GROUPS 1 AND 2								
Corning	70	47	71	82	82	9.853	99	1.74
GROUP 2								
Los Molinos	61	38	60	80	62	11.923	99	2.11
Red Bluff	72	48	75	92	72	10.652	99	1.92
Red Bluff (Lincoln)	65	46	61	81	72	9.505	99	1.76
Red Bluff (Ag Comm)	59	32	55	70	78	6.533	99	2.44
GROUPS 2 AND 3								
Chico[c]	80	63	70	92	95	10.654	99	1.51
Marysville	58	35	63	79	60	18.430	99	2.26
Wheatland	67	38	70	88	72	16.864	99	2.32
Live Oak[c]	106	79	117	111	116	4.958	99	1.48
Dunnigan	68	34	63	94	82	19.697	99	2.76
GROUP 3								
Woodland[c]	75	52	69	92	98	12.765	99	1.88
Sacramento (Branch)	68	52	68	68	84	8.089	99	1.62
Sacramento (P St)	70	59	64	67	90	9.994	99	1.53
West Sacramento	74	58	66	78	89	8.799	99	1.53
GROUP 4								
Modesto (J St)	109	92	88	102	155	19.036	99	1.76
Modesto (Oakdale)	83	68	70	81	114	14.324	99	1.68
GROUPS 4 AND 5								
Los Banos	81	72	68	77	112	18.031	99	1.65
Merced	92	72	81	89	132	17.490	99	1.83
Merced (18 and S)	96	85	79	89	138	15.089	99	1.75
Five Points	119	62	106	141	164	16.906	99	2.65
Fresno (Cal State)	113	87	90	113	165	11.788	99	1.90
Fresno (Olive)	132	117	111	124	177	13.475	99	1.59
Parlier[c]	128	91	144	150	136	5.377	99	1.65
GROUP 5								
Goshen	160	120	145	159	220	16.356	99	1.83
Three Rivers	71	51	69	99	67	18.703	99	1.94
Visalia	143	114	135	147	179	8.191	99	1.57
Bakersfield (Chester)	163	157	138	136	211	13.449	99	1.55
Bakersfield (Flower)	144	136	112	132	186	10.652	99	1.66
Kern Refuge[c]	99	87	72	104	124	4.173	99	1.43
Taft[c]	113	105	108	119	124	0.811	<75	1.18

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[a] Data drawn from the period July 1, 1975 through June 30, 1978.

[b] Enclosed values are >1.25 of the total mean, enclosed values are <0.75 of the total mean.

[c] Data from these sites do not meet distribution criteria cited in the text.

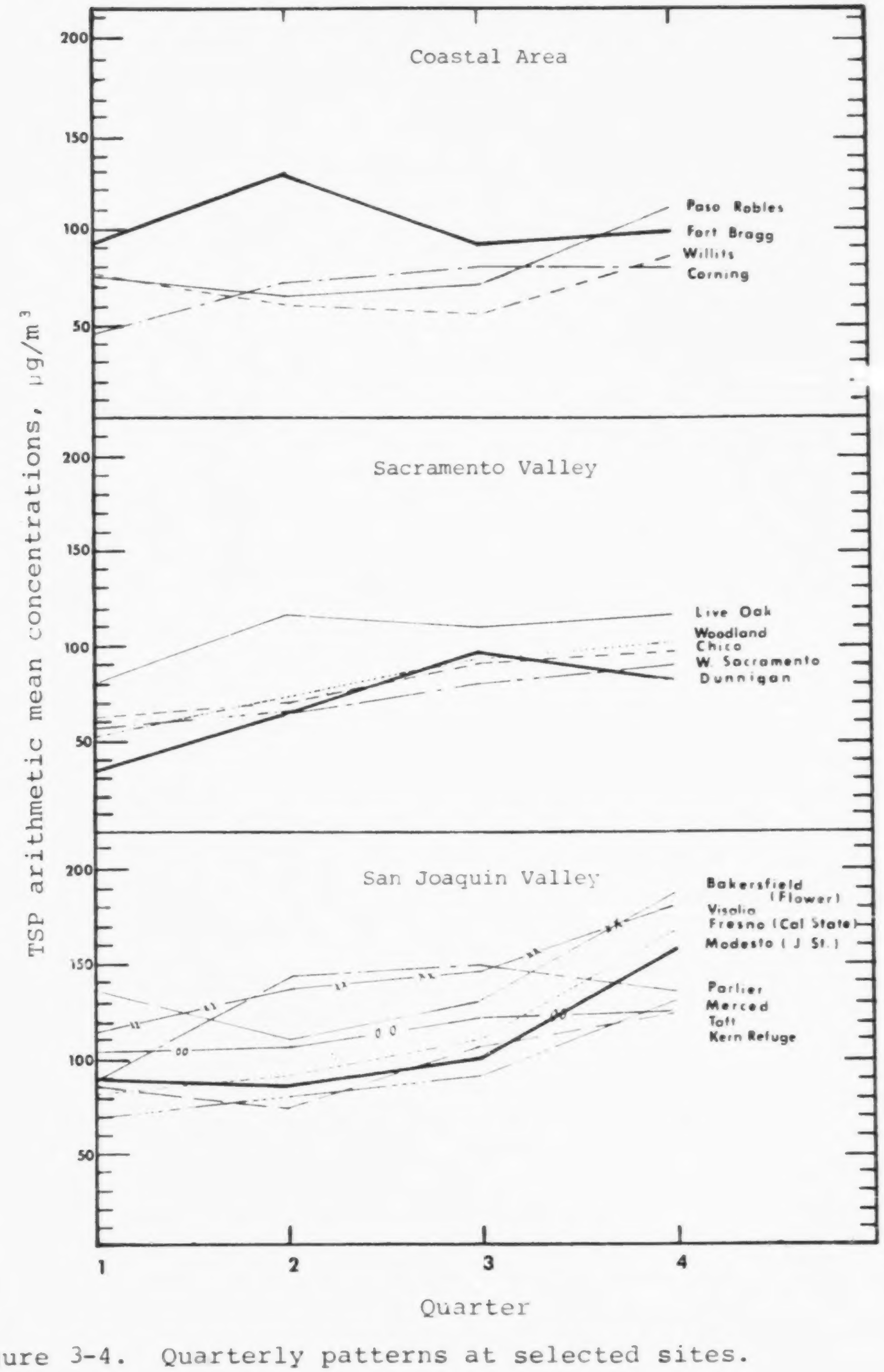


Figure 3-4. Quarterly patterns at selected sites.

f-value which is a function of sample size. If the calculated f-value is greater than the predetermined f-value, then the hypothesis is shown to be false within the selected confidence limits.

Group 2 and 3 Sites--
These two groups represent the Sacramento Valley. Eleven sites [Red Bluff, Red Bluff (Lincoln), Red Bluff (Ag Comm), Corning, Los Molinos, Dunnigan, Marysville, Sacramento (P St), Sacramento (Branch), West Sacramento, and Wheatland] met the inclusion criteria. Data sets of 175, 151, 178, 176, 169, 180, 165, 171, 175, 177, and 196, respectively, were available. Although not meeting the inclusion criteria, Chico, Live Oak, and Woodland were also analyzed. Chico had a data set of 161 samples (second quarter underrepresented). Live Oak and Woodland had sets of 127 and 162 samples. The third quarter was underrepresented at Live Oak and the third and fourth quarters were underrepresented at Woodland.

Patterns for all sites are given in Table 3-1 and shown for selected sites in Figure 3-4. Two distinctly different patterns are evident (both significant at 95 percent confidence level). Chico, Red Bluff (Ag Comm), the three Sacramento area sites, Corning, and Woodland show slight but steady increases throughout the year. Dunnigan, Los Molinos, Red Bluff, Red Bluff (Lincoln), Marysville, and Wheatland, on the other hand, show inverted U patterns peaking in the third quarter. Live Oak is an exception to both patterns, in that it is characterized primarily by unusually low first quarter concentrations. Los Molinos, Red Bluff (Ag Comm), Marysville, Wheatland, and Dunnigan show large (i.e., ratio >2.00) differences between highest and lowest quarterly means, indicating that the dominant emission sources are quite seasonal in character.

Group 4 and 5 Sites--
These two groups represent the San Joaquin Valley. Twelve sites [Modesto (J St), Modesto (Oakdale), Los Banos, Merced, Merced (18 and S), Five Points, Fresno (Cal State), Fresno (Olive), Goshen, Three Rivers, Visalia, and Bakersfield (Chester)] met the inclusion criteria. Data sets of 179, 168, 172, 164, 169, 114, 109, 175, 173, 175, 170, and 202, respectively, were available. Although not meeting the inclusion criteria, Parlier, Taft, Kern Refuge and Bakersfield (Flower) were also analyzed. Parlier had a data set of 132 samples (third and fourth quarters underrepresented). Bakersfield (Flower) had a data set of 154 samples (second quarter underrepresented). Kern Refuge was underrepresented in the second quarter and had a data set of 116 samples. Taft (106 samples) was underrepresented in the last two quarters of the year.

Seasonal patterns for all sites are given in Table 3-1, and shown for selected sites in Figure 3-4. There is one dominant pattern for the valley from which certain sites diverge: a slight increase through the first three quarters followed by a dramatic upsurge in the fourth quarter. Parlier and Three Rivers, both rural sites, show the inverted U-pattern characteristic of many sites in the Sacramento Valley, but Parlier's pattern may be partly a function of the temporal distribution of samples at that site. The two Bakersfield sites show a U-shaped pattern. None of the high quarter to low quarter ratios exceed 2.00. Taft displayed very little variation in concentrations from quarter to quarter.

Day of Week Patterns

Whereas the quarterly means differed from the three year means in a statistically significant manner at all sites analyzed, the daily means only rarely did so. In general, it was found that the variations in daily means were relatively minor and statistically insignificant.

Day of week concentrations, ANOVA results, and ratios of highest to lowest concentrations are given in Table 3-2. Graphical displays of the patterns for regionally representative sites are given in Figure 3-5. Only the Willits' site shows a strong and statistically significant variation from day to day. In that instance, values are at a minimum on Sunday and at a maximum on Thursday.

Summary of Seasonal and Daily Pattern Analyses

In summary, the most significant findings of this analysis are as follows:

- Variations in quarterly means are statistically significant (95 percent confidence level) at all sites except Taft, but variations in daily means are significant at only 3 of the 26 sites.
- Ratios between the highest and lowest quarters are quantitatively significant (i.e., >2.00) at only 6 sites, 5 of which are in the Sacramento Valley. Daily ratios are never quite so quantitatively significant.
- There appear to be two distinct regimes associated with seasonal variations. One is the inverted U-pattern with a maximum in the third quarter, and the other is steadily increasing concentrations with a maximum in the fourth quarter. The former is common in the Sacramento Valley, whereas the latter is common in the San Joaquin Valley and at some sites in the Sacramento Valley and coastal areas.

TABLE 3-2. DAILY MEANS AND ANALYSIS OF VARIANCE FOR SELECTED SITES

Site	Total arith mean[a]	Daily arith mean[a,b] S	M	T	W	Th	F	S	Computed f-value	Probability of difference, %	Ratio of highest to lowest
GROUP 1											
Fort Bragg	101	105	80	96	108	119	106	95	1.092	<75	1.24
Willits	69	58	44	71	79	76	82	81	4.595	99	1.86
Paso Robles	79	75	62	84	84	95	66	86	2.272	95	1.53
GROUPS 1 AND 2											
Corning	70	70	52	68	74	67	77	81	1.469	75	1.56
GROUP 2											
Los Molinos	61	62	48	53	63	55	74	72	1.854	90	1.54
Red Bluff	72	62	57	69	85	68	83	82	2.079	90	1.49
Red Bluff (Lincoln)	65	61	54	60	71	63	69	77	1.137	<75	1.43
Red Bluff (Aq Comm)	59	52	40	62	62	76	60	60	.978	<75	1.90
GROUPS 2 AND 3											
Chico[c]	80	86	70	73	88	76	77	91	1.338	75	1.30
Marysville	58	64	47	52	62	58	59	66	1.037	<75	1.40
Wheatland	67	64	50	67	75	63	73	78	1.670	75	1.56
Live Oak[c]	106	116	92	106	122	96	109	104	1.033	<75	1.33
Dunnigan	68	76	51	65	73	69	70	73	.913	<75	1.49
GROUP 3											
Woodland[c]	75	80	59	73	87	72	75	83	1.118	<75	1.47
Sacramento (Branch)	68	62	48	72	75	75	71	73	2.407	95	1.56
Sacramento (P St)	70	64	56	70	78	71	75	73	1.558	75	1.39
West Sacramento	74	71	60	76	82	76	80	70	1.193	<75	1.37
GROUP 4											
Modesto (J St)	109	107	86	117	110	117	119	107	1.090	<75	1.38
Modesto (Oakdale)	83	81	72	81	87	93	90	79	.728	<75	1.29
GROUPS 4 AND 5											
Los Banos	81	83	65	78	91	79	84	87	1.387	75	1.40
Merced	92	93	77	103	90	96	99	87	.812	<75	1.34
Merced (18 and S)	96	98	85	97	99	99	103	93	.353	<75	1.21
Five Points	119	120	86	120	133	117	147	114	1.341	75	1.71
Fresno (Cal State)	113	116	101	121	129	99	112	114	.461	<75	1.30
Fresno (Olive)	132	133	111	126	149	140	128	132	.980	<75	1.34
Parlier[c]	128	129	99	127	135	141	132	135	.622	<75	1.42
GROUP 5											
Goshen	160	161	132	154	178	186	157	149	1.328	<75	1.41
Three Rivers	71	72	70	73	79	70	69	65	.368	<75	1.22
Visalia	143	146	120	147	161	141	147	139	.881	<75	1.34
Bakersfield (Chester)	163	175	131	166	168	189	152	163	1.820	90	1.44
Bakersfield (Flower)[c]	144	141	120	166	144	174	130	137	1.875	90	1.45
Kern Refuge[c]	99	110	76	95	99	107	101	109	.621	<75	1.45
Taft[c]	113	123	99	100	102	119	124	124	.811	<75	1.25

[a] Data drawn from the period July 1, 1975 through June 30, 1978.

[b] Enclosed values are >1.25 of the total mean, enclosed values are <0.75 of the total mean.

[c] Data from these sites do not meet distribution criteria cited in the text.

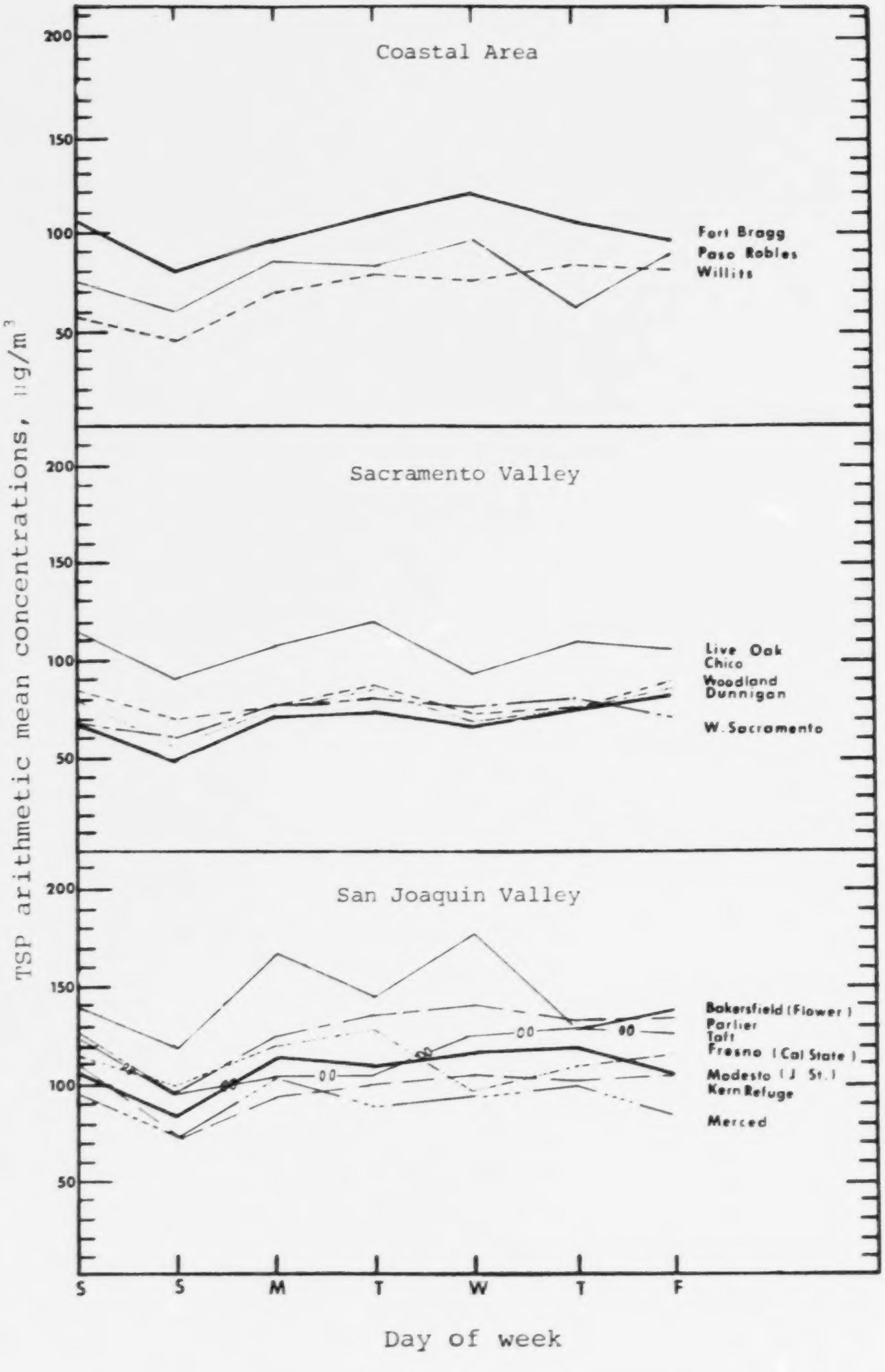


Figure 3-5. Daily patterns at selected sites.

- Certain sites [Fort Bragg, Live Oak, Taft, and Bakersfield (Flower and Chester)] differ from both of the seasonal patterns described.

- Low Sunday concentrations are characteristic of virtually all sites, but only the Willits' site shows a strong and statistically significant day of week variation.

INTERSITE CORRELATIONS

Sites meeting the inclusion criteria were assessed in terms of their intercorrelations. As has been previously indicated, sites were split into five groups. The intent was to determine the extent to which concentrations measured at various sites were influenced by the same variables, hence measured essentially the same air mass.

The strength of the correlations is assessed in three ways: in terms of the intersite correlations, the arithmetic mean correlation for a given site with all other sites in its group, and the arithmetic mean correlation of all sites in the region. The strengths that are found are assigned qualitative descriptors where the sample correlation--given the sample size--can be related to the following population correlation coefficients at a 95 percent confidence level:

Lower bound of population r	Descriptor
0.80 - 1.00	Excellent
0.60 - 0.79	Very good
0.40 - 0.59	Good
0.20 - 0.39	Fair
0.01 - 0.19	Poor
<0.00	Very poor

Group 1 Sites

This group represents coastal sites and nearby sites in the Sacramento or San Joaquin Valleys. Four sites (Willits, Fort Bragg, Paso Robles, and Corning) met the inclusion criteria. Based on the 129 days of data that were available, and using 95 percent confidence limits as a criterion, the following ranges can be used to describe the quality of the observed correlations:

Group 1 sample correlation ranges

>0.85	Excellent
0.70 - 0.85	Very good
0.54 - 0.70	Good
0.36 - 0.54	Fair
0.19 - 0.36	Poor
<0.19	Very poor

Of the six intersite correlations in this group, none are very good or excellent, one (Willits-Paso Robles) is good, one is fair, one is poor, and three are very poor (see Appendix A for the raw correlation matrix.) When the correlations are averaged for each site, only one scores as high as fair. The overall average correlation for the group is poor.

It can be concluded that, with the exception of Paso Robles-Willits, these sites are not sharing the same air mass. That site pair, separated by hundreds of miles, shares the fact that they are both about 30 miles east of the Pacific Ocean. This fact may, in itself, be meaningful.

Group 2 Sites

This group represents the northern and central portions of the Sacramento Valley. Eight sites [Red Bluff, Red Bluff (Lincoln), Red Bluff (Ag Comm), Corning, Los Molinos, Dunnigan, Marysville, and Wheatland] met the inclusion criteria. Based on the 87 days of data that were available and again using 95 percent confidence limits, the following ranges can be used to describe the quality of the observed correlations:

Group 2 sample correlation ranges

>0.86	Excellent
0.73 - 0.86	Very good
0.57 - 0.73	Good
0.40 - 0.57	Fair
0.23 - 0.40	Poor
<0.23	Very poor

Of the 28 intersite correlations in this group, 1 [Los Molinos-Lincoln (Ag Comm)] is excellent, 10 (all in the northern half) are very good, 13 are good, and the remaining 4 are fair. (See Appendix A for the raw correlation matrix.) When the correlations are averaged for each site, 2 (Corning and Los Molinos) rate very good, while the other 6 are good. The overall average correlation for the group is good. A graphical display of these relationships is given in Figure 3-6.

It can be concluded from this analysis that the sites in the central and northern portions of the Sacramento Valley are exposed to very similar air masses and that the emission source/ meteorological variables are quite similar throughout that area. The quality of the average correlations improves, however, when the northern sites and the central sites are treated as two separate groups. Los Molinos and Corning both appear to be very good indicators of the statistical character of regional variations in TSP concentrations.

Group 3 Sites

This group represents the central and southern portions of the Sacramento Valley. Six sites [Sacramento (P St), Sacramento (Branch), West Sacramento, Dunnigan, Marysville, and Woodland] met the inclusion criteria. The ranges indicated for Group 1 can be used to describe the quality of the observed correlations (120 days of data).

Of the 15 intersite correlations in this group, 3 (all among Sacramento sites) are excellent, 3 (all among the central sites) are very good, and the other 9 (Sacramento area sites versus central area sites) are good. Three of the sites' (all Sacramento) average correlations are very good, while the other 3 were good. The overall average correlation is very good. A graphical display of these relationships is presented in Figure 3-6.

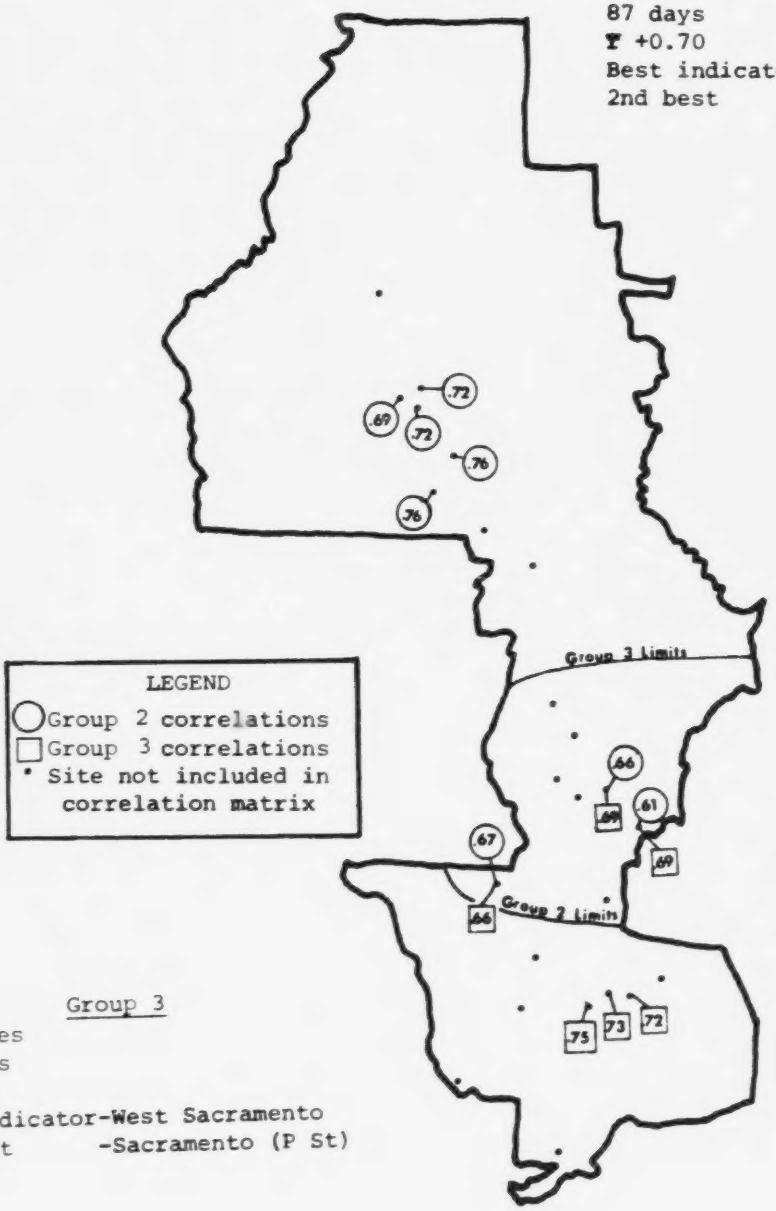
As in the case of Group 2, the correlations within this group indicate that while the central area sites have a slightly different air mass, all of the sites in this part of the Sacramento Valley are impacted by the same types of sources and meteorological conditions. West Sacramento appears to be a very good indicator of the causes of regional variations in TSP concentrations.

Group 4 Sites

The sites in this group are drawn from the northern and central portions of the San Joaquin Valley. Eight sites [Five Points, Fresno (Cal State), Fresno (Olive), Merced, Merced (18 and S), Los Banos, Modesto (J St), and Modesto (Oakdale)] met the inclusion criteria. Figure 3-7 graphically illustrates the

Group 2

8 sites
87 days
$\bar{r}$ +0.70
Best indicator-Los Molinos
2nd best -Corning

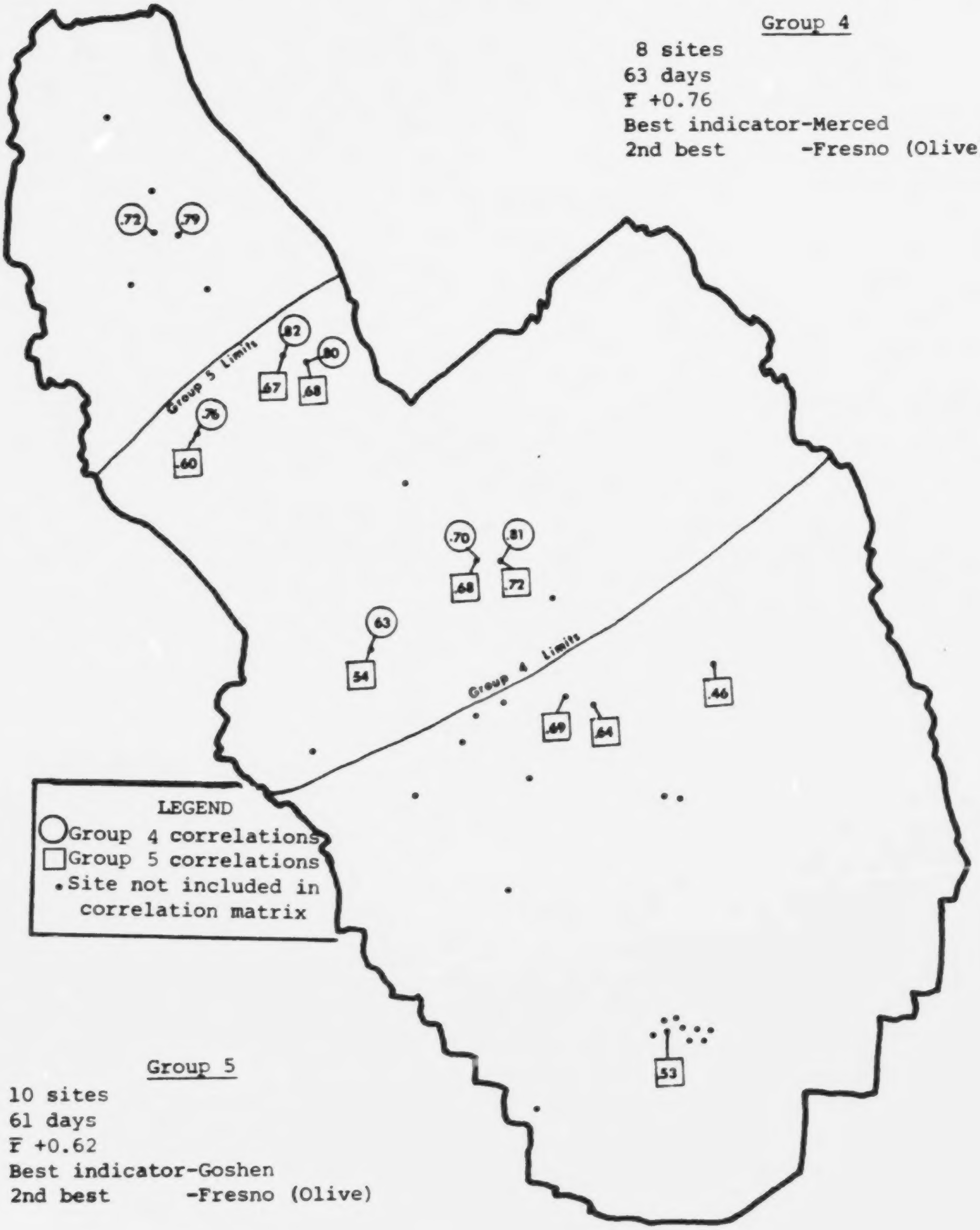

.72
.69
.72
.76
.76
Group 3 Limits
.66
.69
.61
.69
.67
.66
Group 2 Limits
.75
.73
.72

LEGEND
○ Group 2 correlations
□ Group 3 correlations
• Site not included in correlation matrix

Group 3

6 sites
120 days
$\bar{r}$ +0.71
Best indicator-West Sacramento
2nd best -Sacramento (P St)

Figure 3-6. Average intersite correlations in the Sacramento Valley.


.72
.79
.82
.80
.67
.68
.76
.60
Group 5 Limits
.70
.81
.68
.72
63
54
Group 4 Limits
.46
.69
.64
.53
LEGEND
○ Group 4 correlations
□ Group 5 correlations
• Site not included in correlation matrix

Group 4

8 sites
63 days
$\bar{r}$ +0.76
Best indicator-Merced
2nd best -Fresno (Olive)

Group 5

10 sites
61 days
$\bar{r}$ +0.62
Best indicator-Goshen
2nd best -Fresno (Olive)

Figure 3-7. Average intersite correlations in the San Joaquin Valley.

relationships that were found. The following ranges can be used to describe the quality of the observed correlations (63 days of data):

Group 4 sample correlation ranges

>0.87	Excellent
0.74 - 0.87	Very good
0.58 - 0.74	Good
0.43 - 0.58	Fair
0.25 - 0.43	Poor
<0.25	Very poor

Of the 28 intersite correlations in this group, 3 [Fresno (Olive)-Merced, Fresno (Olive)-Merced (18 and S), and Merced-Merced (18 and S)] were excellent, 14 were very good, 9 were good, and 2 [between Five Points, a central rural site, and Modesto (J St) and Fresno (Cal State)] were fair. Five of the average correlations were very good, while the other 3 [Five Points, Fresno (Cal State), and Modesto (J St)] were good. The overall average correlation is very good.

The most immediately apparent fact is that the sites in this grouping all share essentially the same air mass. The site with the most unique characteristics (Five Points) has fair to good relationships with the other sites, indicating that it is most susceptible to impact from localized sources. There are very good or excellent relationships between Los Banos and the nearby Merced sites, between the two Merced sites, between the two Modesto sites, and between the two Fresno sites. Merced appears to be a very good indicator of the statistical character of regional variations in TSP concentrations.

Group 5 Sites

Figure 3-7 graphically illustrates the relationships found among these 10 central and southern San Joaquin Valley sites: Five Points, Fresno (Cal State), Fresno (Olive), Bakersfield (Chester), Merced, Los Banos, Merced (18 and S), Visalia, Three Rivers, and Goshen. The ranges specified for Group 4 can be used to assess the quality of these relationships (61 days of data).

Of the 45 intersite correlations in this group, 3 [Fresno (Cal State)-Fresno (Olive), Merced-Merced (18 and S), and Fresno (Olive)-Merced (18 and S)] are excellent, 8 are very good, 16 are good, 13 are fair, and the remaining 5 [Five Points (a rural site)-Bakersfield (Chester), and Three Rivers (an eastern slope rural site) with Bakersfield (Chester), Merced, Los Banos, and Merced (18 and S)] are poor. None of the average correlations are either excellent or very good, seven are good, and the remaining three [Five Points, Bakersfield (Chester) and Three Rivers] are fair. The overall average correlation for the group is good.

The sites within this group show poorer correlations than do the sites in Groups 2, 3, or 4, indicating that emission source/meteorological variables vary to a greater degree than they do in the other three groups. As in the case of Group 4, the Five Points' site has only a fair relationship with the other sites. A significant fact is that its only poor relationship is with the Bakersfield (Chester) site. The implication is that the sources at Five Points are different from those at other sites in the group. Three Rivers has the weakest average relationship, having as much as a good correlation with only two sites (Five Points and Goshen). This site seems to be impacted by different variables than are the other sites. With the exception of Five Points, Bakersfield (Chester) displays progressively stronger relationships with sites farther south along the valley. The implication is that the air mass changes as it moves farther south. Goshen appears to be a good indicator of regional variations, but it is not as good as some of the other group indicators that have been identified.

One-on-One Intersite Correlations

In addition to the correlations presented above, one-on-one correlations were also computed for 12 of the special study sites and sampling sites located within 50 miles of those sites. The data sets differ for each pair of sites, hence the correlation coefficients cannot be compared with one another directly. Rather, the sample correlations have been converted (to qualitative indicators) to give a general impression of the degree to which special study sites are representative of the 50 mile radius areas surrounding them. A summary of these data is presented in Appendix A.

Figure 3-8 visually indicates the results of this analysis for these special study sites in the Sacramento Valley. The clear indication is that Chico and Woodland are quite representative of the central and southern portions of the valley. Live Oak, on the other hand, displays weaker relationships with surrounding sites and shows some evidence of being impacted by a significant and highly localized source.

Figure 3-9 presents a similar display for the northern San Joaquin Valley. Merced appears to be quite representative of its surrounding sites; however, Modesto (J St) appears less so. A

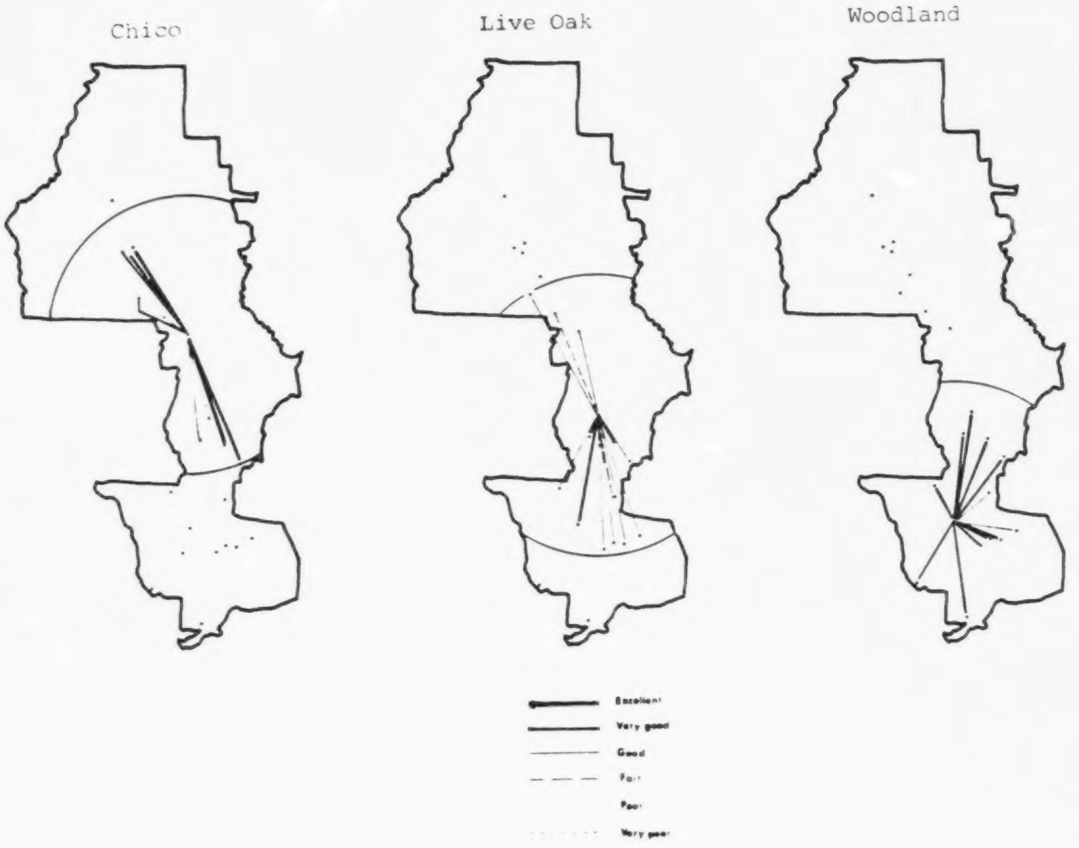

Chico
Live Oak
Woodland
Excellent
Very good
Good
Fair
Poor
Very poor

Figure 3-8. Intersite correlation patterns in the Sacramento Valley.

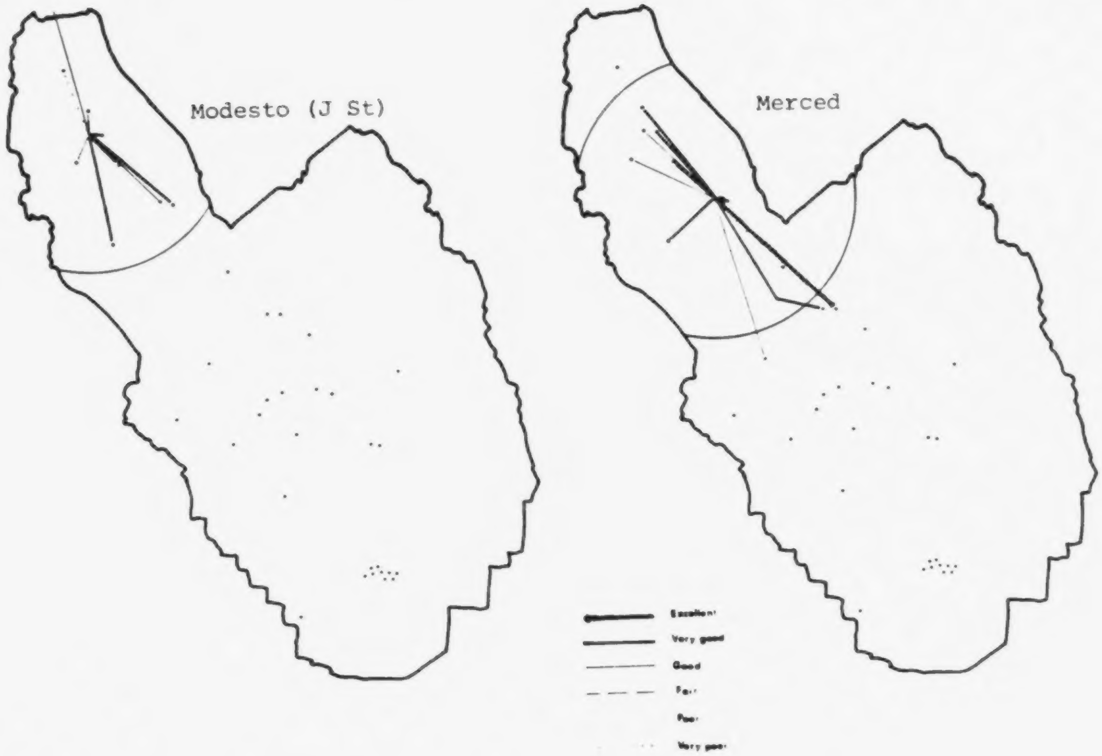

Modesto (J St)
Merced
Excellent
Very good
Good
Fair
Poor
Very poor

Figure 3-9. Intersite correlation patterns in the northern San Joaquin Valley.

startling finding (see Appendix A) is that the sample correlation between Stockton and Modesto (J St) is only +0.09. This is an extraordinarily weak relationship relative to the others presented in this section and suggests that the TSP data for Stockton is unique and perhaps suspect.

The central San Joaquin Valley is displayed in Figure 3-10. Visalia appears to be fairly representative of its surrounding area; however, the other sites do not. Both Parlier and Fresno (Cal State) appear to have only weak relationships with Kings County sites. Five Points has an especially weak relationship with its surrounding sites. One clear pattern that emerges is that of strong relationships between sites located parallel to California Highway 99.

Displayed in Figure 3-11 are southern San Joaquin Valley sites. Kern Refuge, Bakersfield (Chester), and Taft appear to have good relationships with nearby sites; however, none of these sites show the strength of sites located in the northern part of the valley.

Summary of Intersite Correlation Results

Table 3-3 summarizes the results of the grouped correlations discussed in the five preceding subsections. In general, it can be said that the correlations were found to be unexpectedly high. Within cities, average sample correlations of 0.55-0.65 have been found in Philadelphia, Kansas City, and Phoenix; 10 sites throughout Iowa had an average correlation of about 0.65 (confidence limits unknown).[1,2,3] The inference is that the Sacramento Valley and the San Joaquin Valley each display significant uniformity in TSP variations and, by deduction, emission source/meteorological variables. The data presented in the preceding subsections generally support this inference. Only Live Oak, Five Points, Stockton, and Three Rivers show evidence of having highly idiosyncratic patterns of TSP concentrations.

EFFECT OF DAYS SINCE PRECIPITATION

The effect of increasingly drier soil conditions upon TSP concentrations was investigated at four sites [Bakersfield (Flower), Fresno (Cal State), Parlier, and Modesto (J St)] by calculating the average concentration for varying days since precipitation intervals.

Summarized in Table 3-4 and Figure 3-12, the results indicate that days since precipitation is an extremely important variable at the four sites investigated.

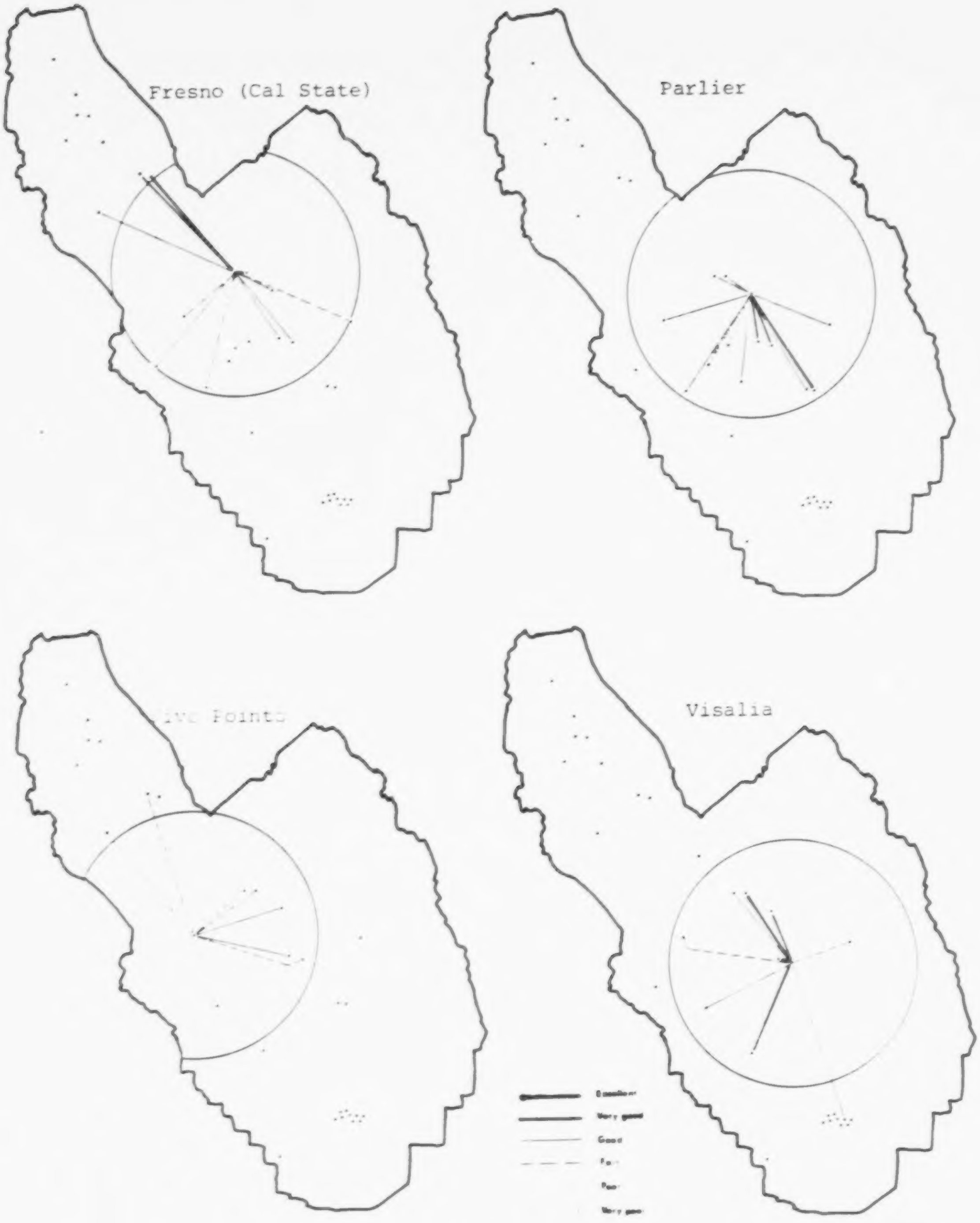

Fresno (Cal State)
Parlier
Five Points
Visalia
Excellent
Very good
Good
Fair
Poor
Very poor

Figure 3-10. Intersite correlation patterns in the central San Joaquin Valley.

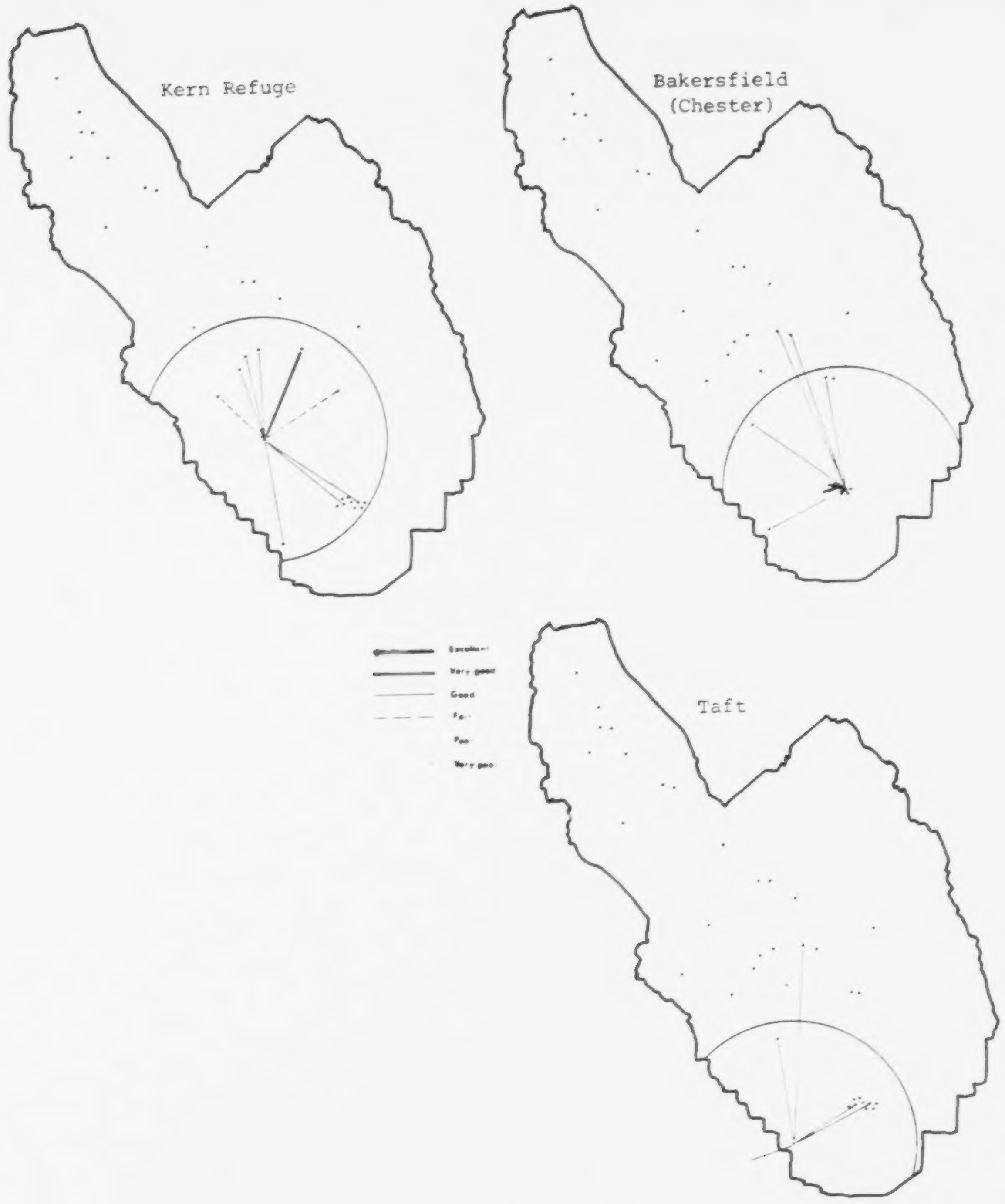

Kern Refuge
Bakersfield
(Chester)
Excellent
Very good
Good
Fair
Poor
Very poor
Taft

Figure 3-11. Intersite correlation patterns in the southern San Joaquin Valley.

TABLE 3-3. SUMMARY OF INTERSITE CORRELATIONS

Group	No. of sites	No. of days	Average correlation	Variation of correlations						Best indicator
				Excl	Very good	Good	Fair	Poor	Not sig	
1	4	129	Poor	-	-	1	1	1	3	None
2	8	87	Good	1	10	13	4	-	-	Los Molinos, Corning
3	6	120	Very good	3	3	9	-	-	-	W. Sacramento
4	8	63	Very good	3	14	9	2	-	-	Merced
5	10	61	Good	3	8	16	13	5	-	Goshen

TABLE 3-4. TSP CONCENTRATIONS VERSUS DAYS SINCE MEASURABLE PRECIPITATION ($\mu g/m^3$)

	Bakersfield (Flower)		Fresno (Cal State)		Parlier		Modesto (J St)	
	Precipitation at sites, in.							
Days since precipitation	>.01	>.25	>.01	>.25	>.01	>.25	>.01	>.25
0	61.4	68.8	53.9	38.4	38.1	29.4	81.1	92.5
1-5	128.1	81.3	94.0	77.1	118.2	56.4	88.9	82.7
6-10	149.7	126.2	109.0	92.6	166.2	104.9	106.3	82.9
11-15	129.6	130.2	112.7	109.7	172.6	118.4	128.4	105.7
16-20	150.1	148.2	128.2	130.7	160.0	147.2	142.2	109.3
21-25	166.6	153.0	141.8	124.8	174.3	197.6	118.7	126.2
26-30	187.8	182.9	133.3	129.7	182.4	155.3	136.0	121.3
>30	142.7	144.5	138.0	136.3	167.9	164.0	119.0	120.9

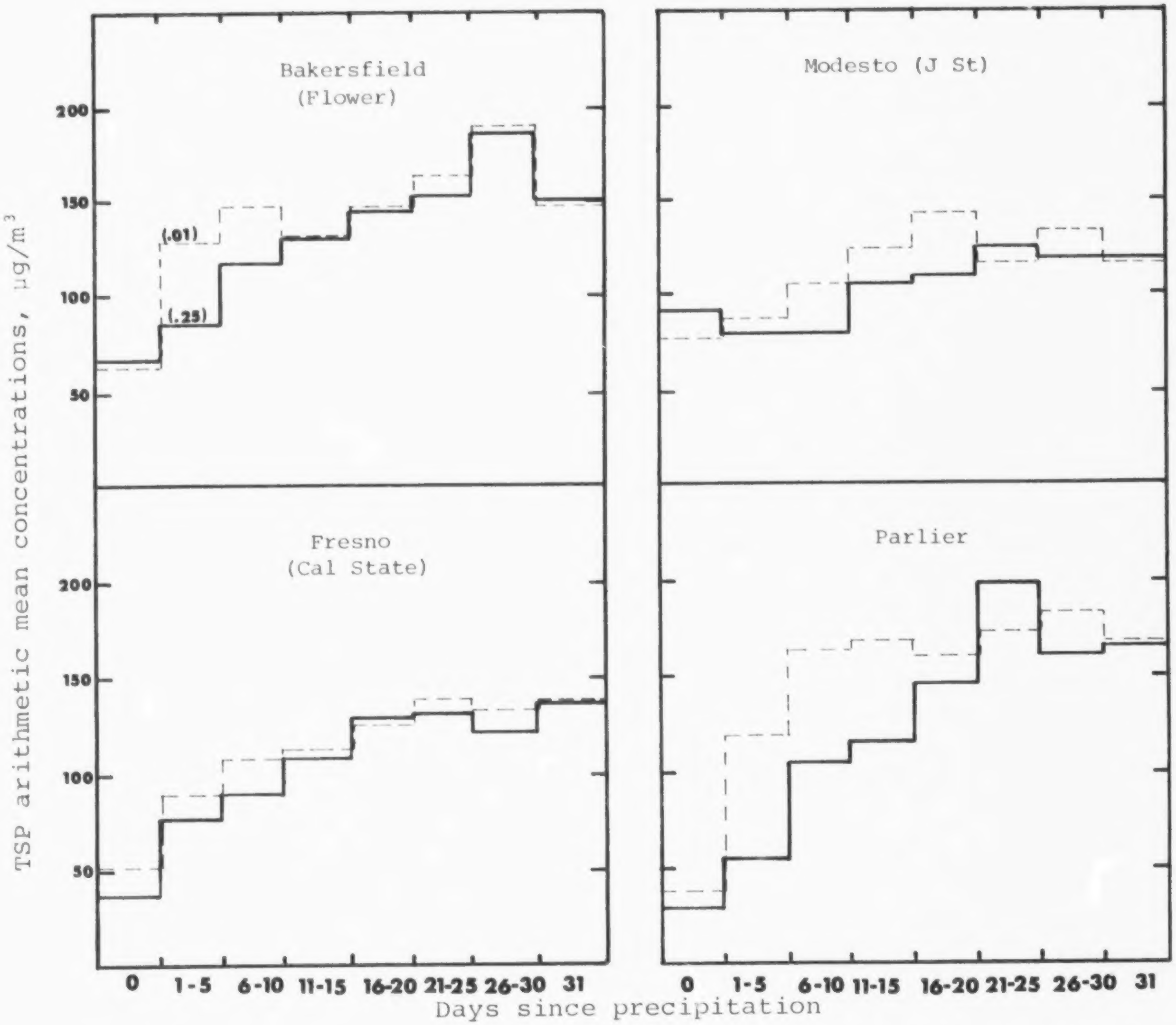


Figure 3-12. TSP concentrations versus days since precipitation, >.01 in. and >.25 in.

The effect of small amounts of precipitation (i.e., >0.01 in.) is significant at Parlier and Bakersfield (Flower) through about the tenth day, at which time the effect disappears. At Fresno (Cal State), the effect of that amount of precipitation appears to continue through about the twenty-fifth day. The effect of larger amounts of precipitation (i.e., >0.25 in.) is much greater. Not only does the effect continue for longer periods of time [through 25 days at Parlier, 20 days at Fresno (Cal State), and 30 days at Bakersfield (Flower)], but also the effect is considerably stronger than is that of smaller amounts of precipitation. Modesto (J St) shows little effect from varying periods of dryness.

These data can be interpreted in at least three ways. Although precipitation near these sites is greatest in the spring, the soil becomes progressively drier through the remainder of the year. Thus, to refer to the quarterly patterns previously observed, it may be that these patterns are a result of increasingly drier soil. On the other hand, it will be noted later in this section that region-wide days of high concentrations are associated with inversion conditions that occur in the fourth quarter. Thus, the data in this section may be an artifact of the effect of inversion conditions. A third possible explanation is that the data presented in this section reflect the combined effect of increasingly dry soil in combination with inversion conditions. The data for Modesto (J St) imply that either inversion conditions or fugitive dust is a much less significant variable than it is at the other three sites analyzed.

EFFECT OF WIND SPEED

The effect of wind speed upon TSP concentrations was also investigated at the four sites discussed in the previous subsection.

Figure 3-13 presents the results of linear regression analysis of TSP concentrations versus average daily wind speed at those four sites. The data are stratified into two groups for each site: mid-1975 through December 1976 and January 1977 through mid-1978. Fresno (Cal State) reveals a fair negative correlation for both periods, thus suggesting that the primary impacting sources are not related to windblown dust. Bakersfield (Flower) reveals a similar negative correlation at the higher end of the poor scale, again suggesting that windblown dust is not a major source. Parlier and Modesto (J St), on the other hand, show a very poor correlation between TSP concentrations and wind speed. When compared to the regression lines for the other two sites, these data suggest that windblown dust may have a significant impact at these two sites.

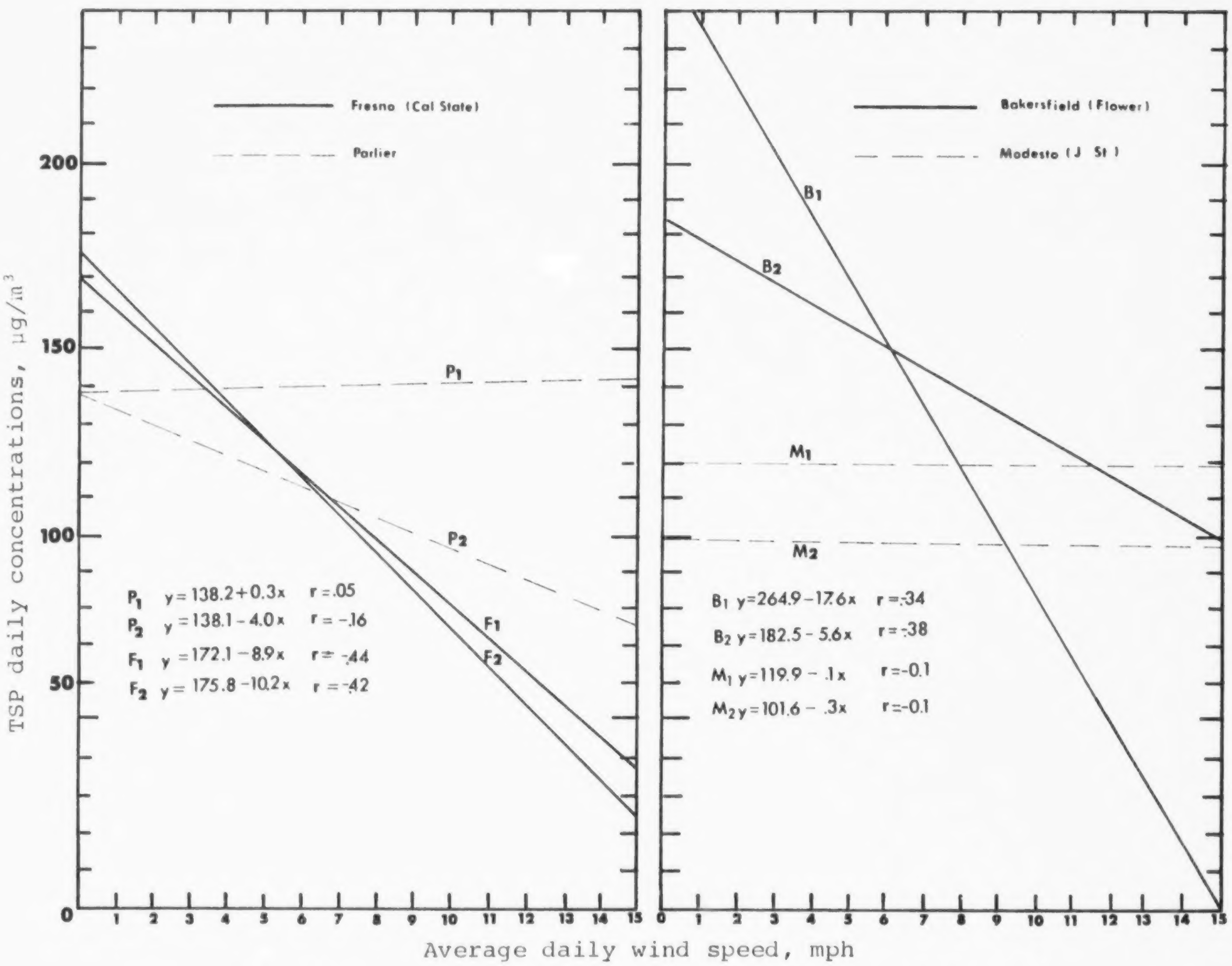


Figure 3-13. Linear regression of TSP versus average wind speed.

The same data are viewed in another way in Figure 3-14. In that figure, average TSP concentrations are plotted for various wind speed ranges. This analysis reinforces the findings presented above.

POLLUTION ROSES

Four pollution roses were constructed for the aforementioned sites to see if specific sources could be pinpointed. Days with concentrations greater than 150 and 260 $\mu g/m^3$ and their associated daily resultant wind directions were identified and are plotted in Figure 3-15.

As that figure indicates, there is a very strong northwest-southeast orientation to the data. This is not surprising in that such an orientation coincides with prevailing valley winds. There are, however, other intriguing patterns. First, the Fresno (Cal State) rose is skewed toward winds from the northwest; second, there is a strong impact upon Parlier from westerly winds; and third, there are fairly strong northerly and easterly impacts in Bakersfield. Although a number of possible explanations can be proposed for these patterns, none are compelling enough to be emphasized at the expense of the others.

ANALYSIS OF DAYS OF REGION-WIDE HIGH CONCENTRATIONS

The same set of sites/days indicated for the analysis of quarterly and daily means were analyzed to see whether there were any region-wide phenomena present. Where such phenomena were indicated, meteorological conditions occurring on these days were defined.

Days of region-wide high concentrations were defined to occur whenever more than 50 percent of the available sites within a group exceeded 150 $\mu g/m^3$ (100 $\mu g/m^3$ in the Sacramento Valley). As Table 3-5 indicates, 19 days were found for Group 2, 11 days for Group 3, 7 days for Group 4, and 10 days for Group 5.

Local climatological data from Bakersfield, Fresno, Stockton, Sacramento, and Red Bluff were investigated to find out what meteorological conditions were present on those days. As Table 3-5 reports, these region-wide violation days were nearly always characterized by the following:

- Light and variable winds
- Very dry to moderately dry atmosphere
- Very dry to moderately dry soils
- In general, inversion conditions

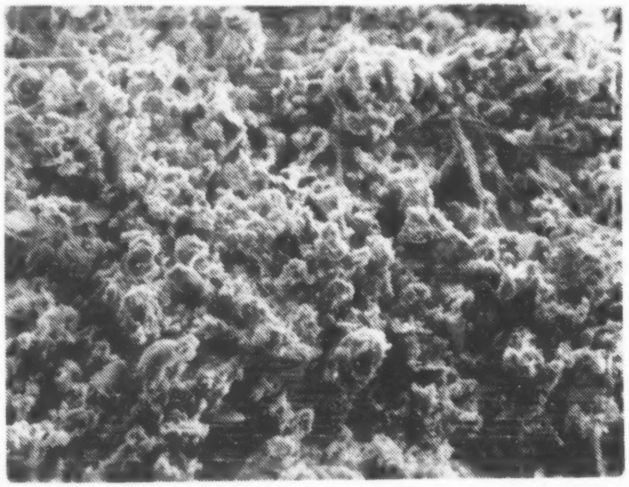


Figure 4-1. Filter sample #26, prior to extraction. (500X).

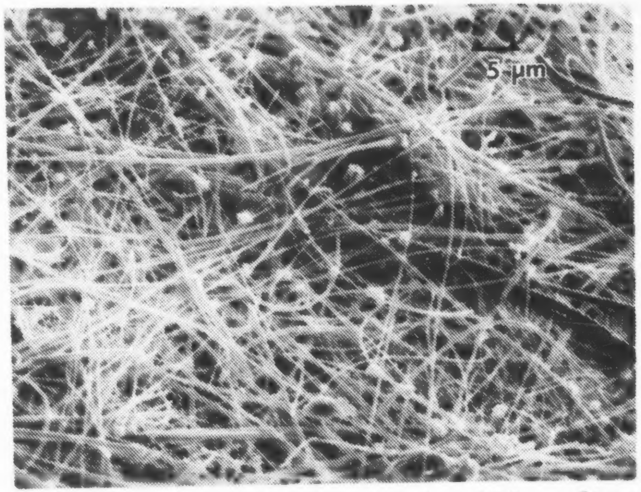


Figure 4-2. Filter sample #26, after extraction. (500X).

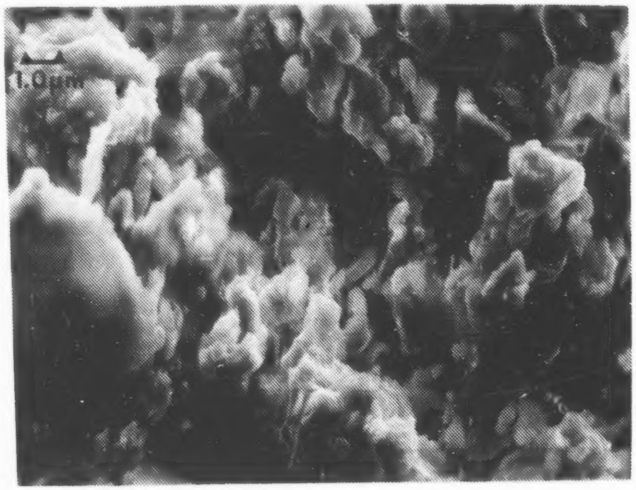


Figure 4-3. Filter sample #26, prior to extraction. (1000X).

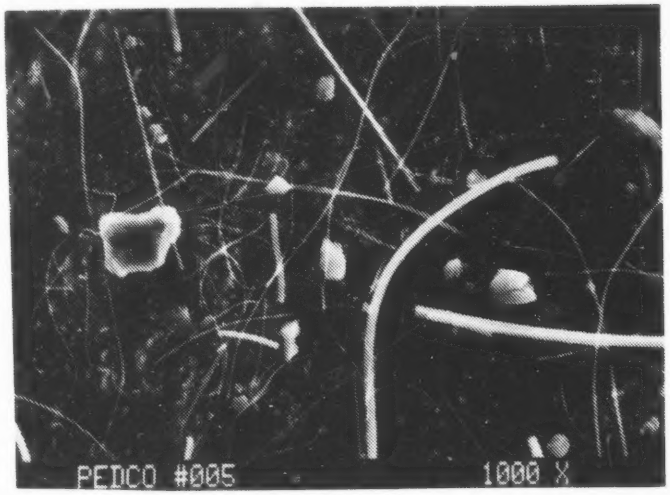

PEDCO #005
1000 X

Figure 4-4. Nuclepore #5. (1000X).

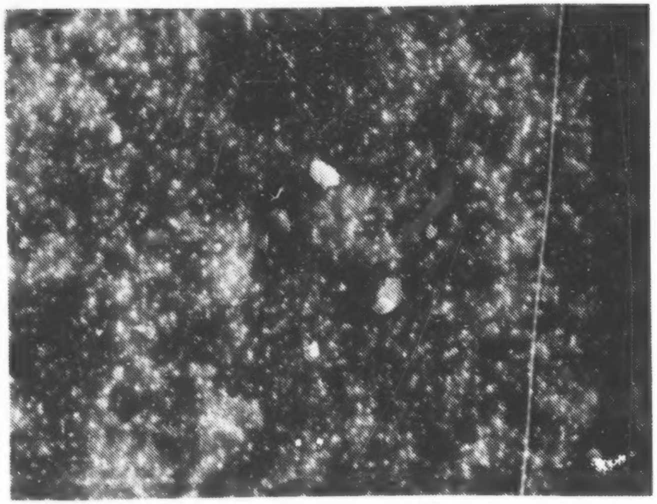


Figure 4-5. Nuclepore #54. (1000X).

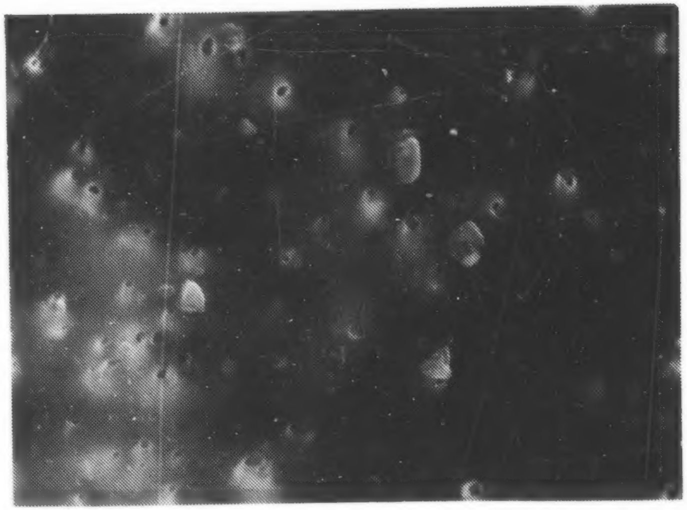


Figure 4-6. Nuclepore #54. (5000X).

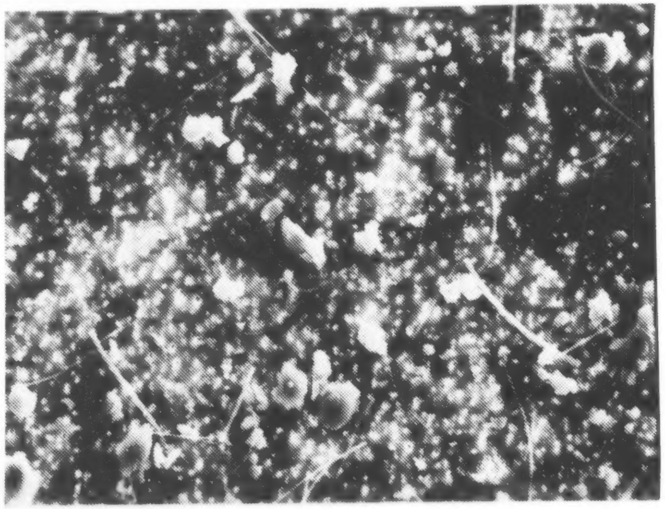


Figure 4-7. Nuclepore #42. (1000X).

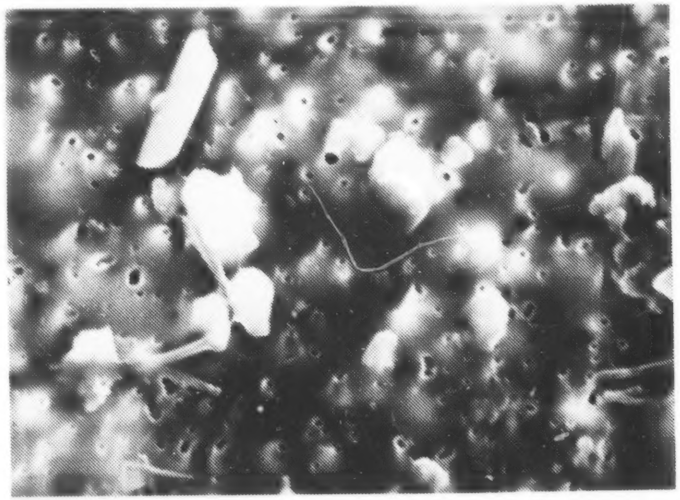


Figure 4-8. Nuclepore #42. (5000X).

From the photographs obtained by using the scanning electron microscope, estimates of mass loading were derived from measured particle sizes and the size of the area observed. For purposes of estimating mass, it was assumed that all particulates were spheres. The diameter was estimated by dividing by 2 an actual particle's longest axis length plus its width at right angles to this axis. As it was also necessary to estimate the mass of the particles, specific gravities were assumed to be 2.0 for C, 2.6 for minerals, 9.0 for Pb, 5.0 for Fe, and 8.0 for particles rich in Cu and Zn. Sample sizes of the particles ranged from 10's for very lightly loaded samples to several hundred for samples that were heavily loaded. By assuming the specific gravity and by using the number of particles in a specific area and the average calculated particle volume, it was possible to estimate mass loadings for any examined field. Mass loadings, in grams cm^{-2}, were calculated using a programmable calculator; fibers were ignored.

Figure 4-9 demonstrates the difficulty of examination when fields are heavily loaded; the small circle is slightly larger than 2.0 µm. All particles this size or greater had to be measured and assayed for elemental composition. Figure 4-10 demonstrates an analysis at higher magnification. All unidentified particulates in that figure are C, i.e., particulates which generated no X-ray or displayed only weak elemental peaks. The number of photos examined was occasionally reduced when loadings were excessively high.

RESULTS OF ANALYSIS

Data reduction sheets for materials examined from each of the 55 filters analyzed are presented in Appendix B. Each of the eight Phase I sites is represented by 6 filters, 2 of high particulate loadings, 2 of moderate loadings, and 2 of light loadings. In addition, 6 more filters from the Merced site and 1 from Visalia were analyzed. Phase II sites were also scheduled to be analyzed, but other postponed commitments, personnel absences, and technical difficulties prohibited DRI from performing this additional work.

In the discussion that follows, references are made to percent contributions by weight of the various particle types to measured particulate matter. It is important to note that these percents do not account for the sulfates, nitrates, and nonpolar organics which were removed by the extraction process, or for cotton fibers which, if present, were assumed to be glass fibers. Thus, if the $SO_4^=$ concentration was 10 percent of the TSP, a DRI-reported mineral contribution of 80 percent would actually be 72 percent. Unfortunately, it is not possible to quantify the amount of material that was lost.

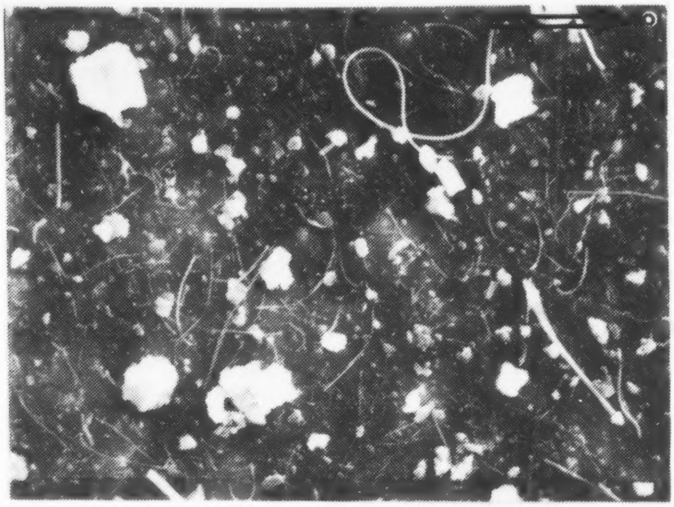


Figure 4-9. Nuclepore #13. (1000X), circle ∿2.0 μm.

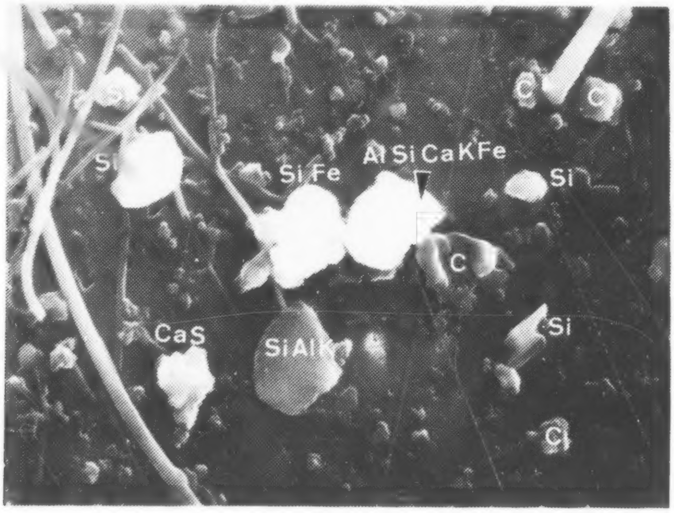

Si
C
C
Si
Si Fe
Al Si Ca K Fe
Si
C
CaS
Si Al K
Si
Cl

Figure 4-10. Nuclepore #13. (5000X). Unidentified particles, except fibers, are carbon.

In general, it was observed that minerals were usually the predominant particulate type by mass. It was also observed, however, that the C particulates of an unspecified origin were usually present in significant amounts. This is important because the amount of organic material dissolved by the DMF solvent was unknown. As documented in the following information, this is especially true of the Parlier, Fresno (Cal State), and Merced sites. Larger C particulates usually were indistinguishable from mineral particles (Figure 4-11, B) and were the predominant carbonaceous particulate by mass throughout all samples. Definite biological materials, such as the pollen grain (A) in Figure 4-11, were always <10 percent of the carbonaceous fraction. Smaller C particulates, which rarely contributed much sample mass, were more distinctive (see Figure 4-12): agglomerates of relatively large particles (A), which were rare; chunks identical to mineral particles (B); small flakes (C); and very tiny particles (D), which were often found as agglomerates. A large number of such tiny particles can be seen in Figure 4-13. The only other particulates of general interest were: (1) CuZn, which showed up as one or two particles in almost every sample and may reflect the effect of hi vol motor bushings; and (2) Pb, which showed up in a number of samples in small quantities but occasionally, particularly in Fresno, in very significant amounts (e.g., Figure 4-13).

Table 4-1 summarizes the percent contributions by particle type and size that were found for the eight special study site filters. In order to calculate these contributions, measured fractions were weighted by the TSP concentrations measured by ARB for these filters. As a weighted average of measurable particulate matter at all eight sites, large mineral particles (i.e., >2.0 μm) contribute ~65 percent to the measured mass. Large carbonaceous particles contribute ~18 percent, small mineral particles contribute ~12 percent, small carbonaceous particles contribute ~4 percent, and other particle types (i.e., salts, metals, and S-rich particles) contribute ~1 percent.

The question arises whether there is a significant difference between the contributions found at the San Joaquin Valley sites and those found at the Sacramento Valley sites. According to Figure 4-14, there is a difference insofar as the Sacramento Valley sites have a significantly greater mineral particle contribution than the San Joaquin Valley sites. An average of 84.5 percent of the Sacramento Valley sites' particulate matter is mineral, whereas 73.8 percent of the San Joaquin Valley sites is contributed by that component. Or, viewed from a different perspective, carbonaceous material is present in much greater quantities in the San Joaquin Valley than in the Sacramento Valley (i.e., 24.3 percent versus 15.6 percent).

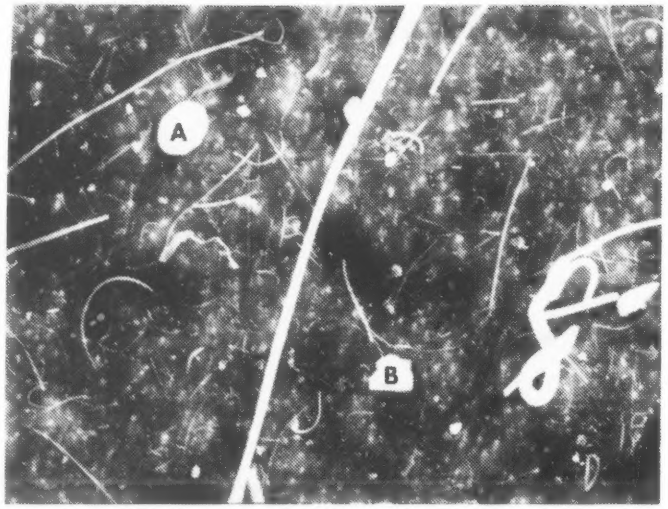


Figure 4-11. Nuclepore #15. (1000X).

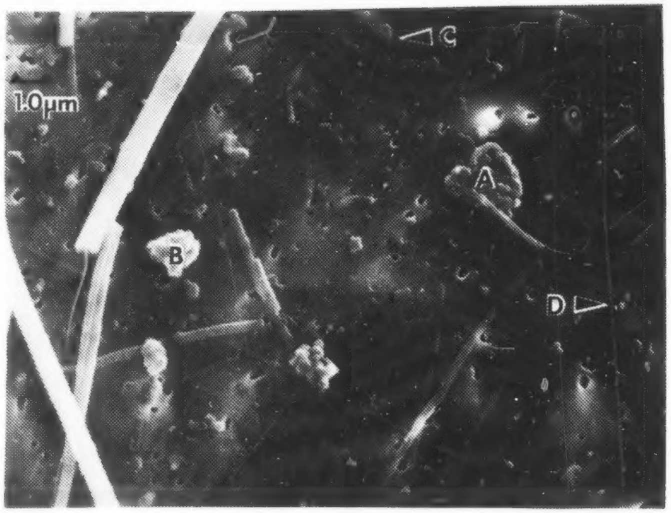


Figure 4-12. Nuclepore #13. (5000X).

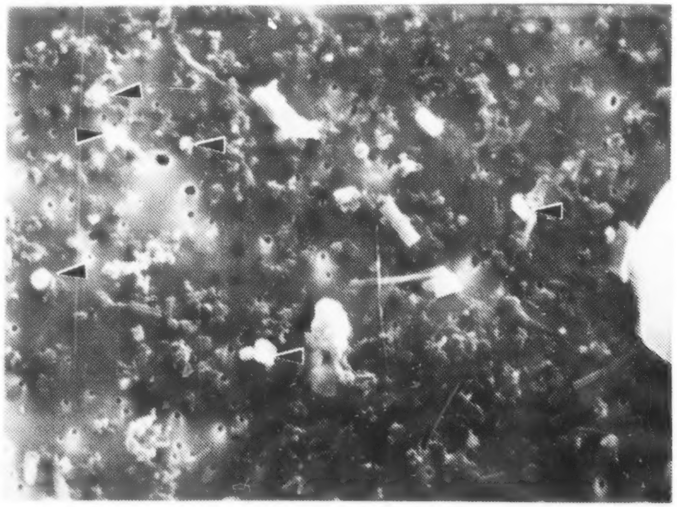


Figure 4-13. Nuclepore #37. (5000X). Marked particles are lead.

TABLE 4-1. SUMMARY OF MICROSCOPY ANALYSES

Site	TSP conc, μg/m³	Percent contribution[a]		
		Mineral	Carbonaceous	Other
Bakersfield (Flower)	176.0			
>2.0 μm		75.0	14.9	-
<2.0 μm		7.1[b]	2.7	0.4 (metals)
Parlier	186.7			
>2.0 μm		51.9	27.7	-
<2.0 μm		16.5	3.8	-
Fresno (Cal State)	105.0			
>2.0 μm		48.1	17.2	0.9(salts), 7.3 (metals)
<2.0 μm		9.5	14.3	0.1(S-rich), 2.3(metal), 0.4(salts)
Merced	97.5			
>2.0 μm		65.2	22.6	-
<2.0 μm		9.4	2.8	-
Modesto (J St)	125.0			
>2.0 μm		75.3	15.1	-
<2.0 μm		8.0	1.6	-
Woodland	112.0			
>2.0 μm		66.6	14.9	-
<2.0 μm		15.3	3.5	-
Live Oak	131.5			
>2.0 μm		79.4	13.8	-
<2.0 μm		5.6	1.2	-
Chico	80.5			
>2.0 μm		59.3	11.4	-
<2.0 μm		28.1	1.2	-
All sites	126.8			
>2.0 μm		65.4	17.8	0.8(salts and metals)
<2.0 μm		11.8	3.8	0.4(salts, metals, and S-rich)

[a] Values reflect weighted means.

[b] Enclosed values exceed the eight-site means by >30 percent; other enclosed values are <70 percent of the means.

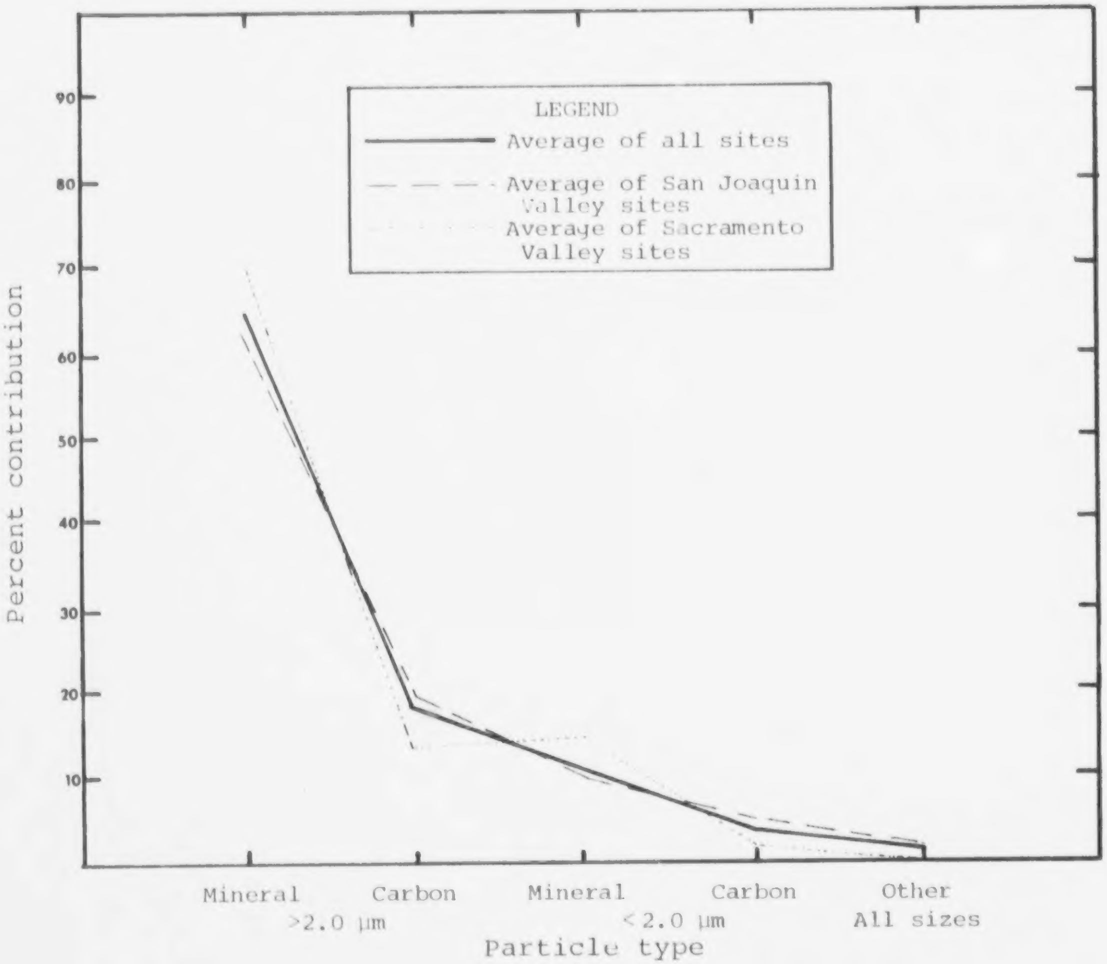


Figure 4-14. Average particle type contributions by site location.

Using these average distributions as a standard, the distributions at each individual site can be assessed for unusual deviations. Compared to the eight-site average, the Bakersfield (Flower) site has an unusually low percent contribution from small mineral particles, suggesting that most of its mineral component is generated by local sources. Parlier data reveal an unusually high percent contribution from large carbonaceous particle and small mineral particle components. The mineral component probably reflects middle-range transport, whereas the carbonaceous component probably reflects rather short-range transport or localized combustion processes. Fresno (Cal State) shows a very high percent contribution from small carbonaceous particles, as well as significant amounts of metals, especially lead and salts. This almost certainly reflects the effect of automotive traffic within that city. Low percent contributions from both of the major small particle components characterize the filter loadings at both Modesto (J St) and Live Oak, implying that local sources have a predominant effect upon these samplers. Chico is relatively low in both carbonaceous particle size ranges and relatively high in small mineral particles. This can be inferred to mean that there is an absence of significant combustion sources and a probable exposure of the sampler to regional-scale windblown dust.

The question then is whether there is any significant variation in particle type contributions when TSP loadings are stratified into heavy, moderate, and light filter loading ranges. Weighted averages for each site are given in Table 4-2. This table and Figure 4-15 suggest that, on the average, higher TSP loadings can be characterized by increased contributions from large mineral particles. There is, however, great variation in the data. Given the sample sizes (n = 2) involved in computing the TSP stratified means for each site, no great confidence should be placed in these values.

Tables 4-3 through 4-10 summarize the data that were produced for each site's filters, and describe the meteorological conditions that were present on the days of sampling. Inversion conditions, defined by the presence of light and variable winds, existed on virtually every day with a high TSP loading. This fact, coupled with the dominance of large mineral particles, suggests that mechanically entrained fugitive dust generated within a few miles of each of the sampling sites was responsible for the major portion of observed TSP concentrations.

CONCLUSIONS

Glass fiber filters are probably the worst possible media for particulate analysis. The problems associated with resuspension and redistribution can and will cause analytical problems. This problem is compounded when a solvent and rigorous

TABLE 4-2. PERCENT CONTRIBUTION TO TSP BY PARTICLE TYPE, PARTICLE SIZE, AND TSP LOADINGS

Site	Percent contribution[a]						
	Mineral			Carbonaceous			Other
	High	Mod	Low	High	Mod	Low	All ranges
Bakersfield (Flower)							
>2.0 µm	73.7	79.4	67.2	15.8	13.1	12.6[b]	0.4
<2.0 µm	6.9	4.7	16.9	3.5	1.2	2.1	
Parlier							
>2.0 µm	47.5	62.0	61.8	28.4	27.2	21.7	neg
<2.0 µm	20.8	4.5	13.4	3.1	6.3	3.0	
Fresno (Cal State)							
>2.0 µm	54.1	36.2	48.2	11.7	21.7	29.0	8.2 (metals and salts)
<2.0 µm	3.6	17.7	17.0	12.7	19.1	5.2	2.8 (metals, salts, and S-rich)
Merced							
>2.0 µm	69.8	69.9	12.1	20.7	20.9	40.9	neg
<2.0 µm	6.9	5.4	40.9	2.3	3.3	4.1	
Modesto (J St)							
>2.0 µm	77.8	75.9	57.9	14.5	14.7	19.8	neg
<2.0 µm	6.4	7.7	17.3	1.1	1.8	3.2	
Woodland							
>2.0 µm	74.0	52.2	25.7	11.7	19.4	38.5	neg
<2.0 µm	11.2	24.7	27.2	3.1	3.7	8.6	
Live Oak							
>2.0 µm	81.4	87.3	55.9	10.9	8.5	36.0	neg
<2.0 µm	6.5	3.7	4.8	1.2	0.4	3.3	
Chico							
>2.0 µm	69.9	35.9	64.6	12.0	11.0	8.8	neg
<2.0 µm	17.0	52.1	22.3	0.8	1.1	4.3	
All sites							
>2.0 µm	67.4	64.8	53.1	16.8	17.2	25.6	2.9
<2.0 µm	10.6	12.7	17.2	3.4	4.5	3.8	

[a] Values reflect weighted means.

[b] Enclosed values exceed the eight-site means by >30 percent; other enclosed values are <70 percent of the means.

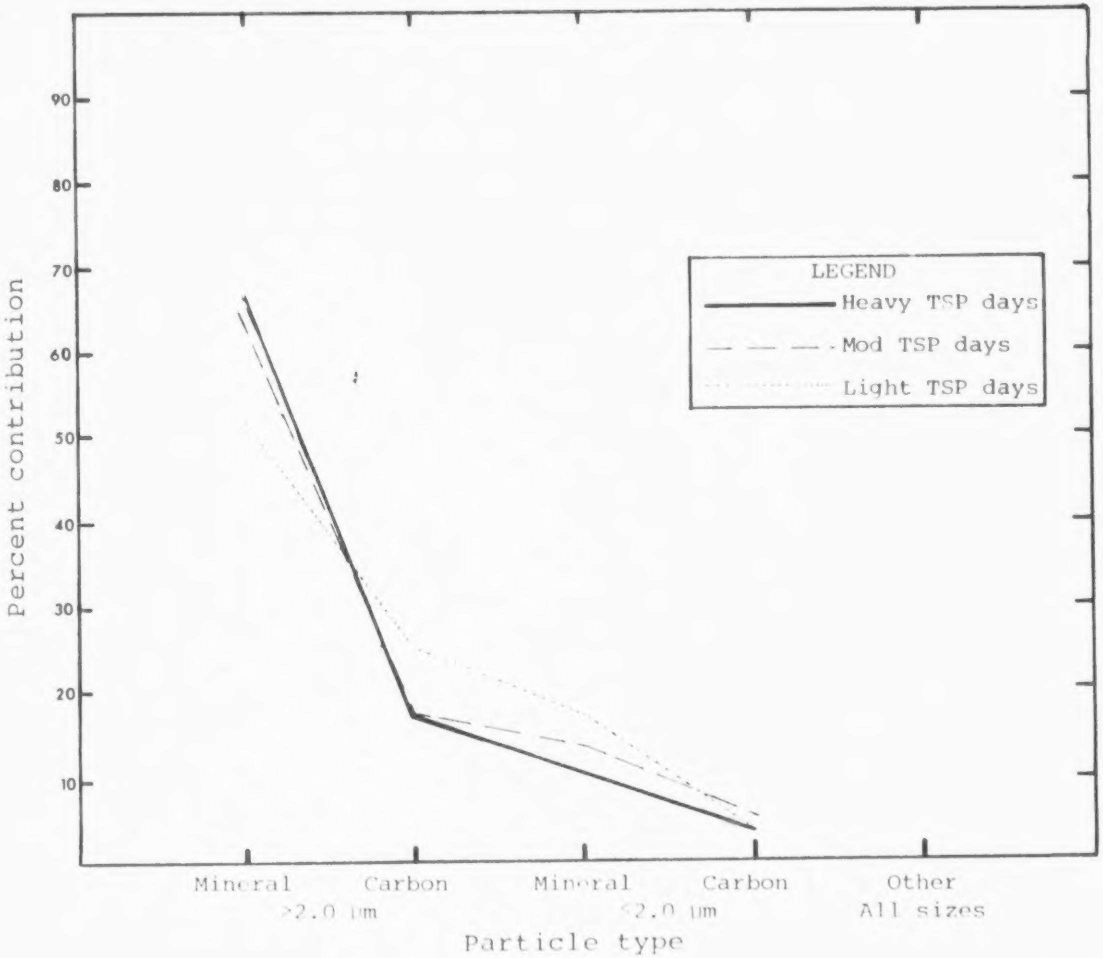


Figure 4-15. Eight-site average for particle type contribution to stratified TSP loadings.

TABLE 4-3. SUMMARY OF BAKERSFIELD (FLOWER) MICROSCOPY ANALYSES

Date	Meteorological conditions	TSP, $\mu g/m^3$	Percent contribution			
				Mineral	Carbonaceous	Other
03/08/77	Extremely light and variable winds, smoke and haze, moderately dry atmosphere, very dry soil, probable inversion condition	144	>2.0μm	66.5	21.5	neg (fly ash)
			<2.0μm	7.5	1.5	3.0 (metals)
12/20/76	Same as 03/08/77	353	>2.0μm	70.9	15.6	neg (fly ash)
			<2.0μm	8.9	4.5[a]	0.0
12/02/76	Same as 03/08/77	332	>2.0μm	76.8	16.1	0.0
			<2.0μm	4.7	2.4[a]	0.0
03/02/76	Light and variable winds, partly cloudy, moderately dry atmosphere, wet soil, possible frontal passage condition	37	>2.0μm	61.1	16.8	0.0
			<2.0μm	20.1	2.0[b]	0.0
05/01/77	Moderately strong and persistent winds from the north, very dry atmosphere, dry soil. Possibly cold frontal passage condition	48	>2.0μm	73.3	9.7	neg (metals)
			<2.0μm	14.7	2.2	neg (metals)
10/10/77	Same as 03/08/77	144	>2.0μm	92.3	5.0	0.0
			<2.0μm	1.9	0.8[b]	0.0
Arithmetic mean[c]		176	>2.0μm	75.0	14.9	neg
			<2.0μm	7.1	2.7	0.4 (metals)

[a] Agglomerates of small particulates of C (i.e., soot) evident.
[b] C often flake-like.
[c] Particle size data represent a weighted mean.

TABLE 4-4. SUMMARY OF PARLIER MICROSCOPY ANALYSES

Date	Meteorological conditions[a]	TSP, $\mu g/m^3$	Percent contribution			
				Mineral	Carbonaceous	Other
06/23/76	Light and variable winds, slightly dry soil, very dry atmosphere, indicative of inversion	422	>2.0μm	54.8	29.0	0.0
			<2.0μm	13.9	2.2	0.0
03/01/76	Moderate but variable winds, moist atmosphere and soil, rain, storm system	25	>2.0μm	78.6	13.1	0.0
			<2.0μm	5.6	2.7	0.0
11/15/77	Light and variable winds, slightly dry soil and atmosphere, smoke and haze, inversion conditions	134	>2.0μm	73.2	16.4	0.0
			<2.0μm	8.7	1.7	0.0
11/21/77	Moderate and persistent east winds, moist soil and atmosphere, rain, storm system in area	56	>2.0μm	54.3	25.6	0.0
			<2.0μm	16.9	3.2	0.0
01/31/76	Light and variable winds, dry atmosphere and dry soils, smoke, haze, inversion conditions	359	>2.0μm	39.0	27.8	0.0
			<2.0μm	29.0	4.1	0.0
06/18/77	Moderate and persistent west winds, dry atmosphere and soil	124	>2.0μm	49.9	38.8	0.0
			<2.0μm	0.0	11.3	0.0
Arithmetic mean[b]		187	>2.0μm	51.9	27.7	0.0
			<2.0μm	16.5	3.8	0.0

[a] Fresno climatological data used.

[b] Particle size data represent a weighted mean.

TABLE 4-5. SUMMARY OF FRESNO (CAL STATE) MICROSCOPY ANALYSES

Date	Meteorological conditions[a]	TSP, $\mu g/m^3$	Percent contribution			
				Mineral	Carbonaceous	Other
01/01/77	Light and variable winds, moist atmosphere, moist soils, Indicative of maritime air mass	92	>2.0µm	34.8	16.1	5.9 (salts)
			<2.0µm	3.2	35.0	2.4 (metals)[a] 2.7 (salts)
05/01/77	Moderate but variable winds, dry atmosphere, moist soils	37	>2.0µm	37.0	36.1	0.0
			<2.0µm	17.3	8.6	0.9 (S-rich)
08/22/76	Moderate and slightly persistent winds from the west, dry atmosphere, very dry soils	37	>2.0µm	59.4	22.0	neg (metals)
			<2.0µm	16.7	1.8	
12/20/76	Light and variable winds, dry atmosphere, dry soils, smoke and haze, probable inversion condition	247	>2.0µm	47.6	6.1	18.6 (metals)[a]
			<2.0µm	2.8	20.1	4.9 (metals)[a]
06/29/76	Moderate and persistent winds from the WNW, very dry atmosphere, dry soils	124	>2.0µm	67.1	25.6	0.0
			<2.0µm	6.0	1.2	0.0
07/11/76	Strong and persistent winds, extremely dry atmosphere and dry soil	93	>2.0µm	37.5	27.2	0.0
			<2.0µm	32.0	3.3	0.0
Arithmetic mean[b]		105	>2.0µm	48.1	17.2	0.9 (salts) 7.3 (metals)[a]
			<2.0µm	9.5	14.3	0.1 (S-rich) 2.3 (metals)[a] 0.4 (salts)

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[a] Primarily Pb particles.

[b] Particle size data represent a weighted mean.

TABLE 4-6. SUMMARY OF MERCED MICROSCOPY ANALYSES

Date	Meteorological conditions[a]	TSP, µg/m³	Percent contribution			
				Mineral	Carbonaceous	Other
10/27/76	Very light and variable winds, dry atmosphere, dry soil, probable inversion condition	212	>2.0µm	60.2	30.3	0.0
			<2.0µm	7.1	2.4	0.0
06/23/76	Moderate but variable winds, very dry atmosphere, moderate to slightly moist soils	147	>2.0µm	84.0	71.0	neg (metals and salts)
			<2.0µm	6.7	2.2	neg (metals)
11/26/76	Light and variable winds, moderately dry atmosphere, slightly moist soils	81	>2.0µm	52.9	31.4	neg (metals and salts)
			<2.0µm	9.3	6.4	neg (fly ash)
04/13/77	Moderate and persistent winds from the west, very dry atmosphere, dry soils	96	>2.0µm	84.9	12.3	neg (fly ash and S-rich particles)
			<2.0µm	2.1	0.7	0.0
05/01/77	Moderate and somewhat variable winds, dry atmosphere, dry soil until precipitation occurred on that day	21	>2.0µm	19.0	43.2	neg (metals and fly ash)
			<2.0µm	35.6	2.2	0.0
02/06/76	Moderate but variable winds, foggy, moist atmosphere, very moist soils, indicative of storm system	28	>2.0µm	7.3	40.7	0.0
			<2.0µm	46.4	5.6	0.0
Arithmetic mean[b]		98	>2.0µm	65.2	22.6	neg
			<2.0µm	9.4	2.8	neg

[a] Fresno climatological data used.

[b] Particle size data represent a weighted mean.

TABLE 4-7. SUMMARY OF MODESTO (J ST) MICROSCOPY ANALYSES

Date	Meteorological conditions[a]	TSP, μg/m³	Percent contribution			
				Mineral	Carbonaceous	Other
01/25/76	Light and variable winds, dry atmosphere, heavy fog and smog, very dry soils, probably inversion condition	173	>2.0μm	83.4	14.6	neg (S-rich)
			<2.0μm	1.4	0.6	0.0
12/03/77	Light and variable winds, very moist atmosphere, slightly moist soils, foggy, possibly indicative of maritime air mass	274	>2.0μm	74.5	14.5	0.0
			<2.0μm	9.6	1.5	0.0
01/14/78	Very strong and persistent winds from the south, extremely moist atmosphere, heavy precipitation and fog, indicative of storm system	26	>2.0μm	33.9	30.6	0.0
			<2.0μm	32.8	2.6	0.0
05/13/77	Moderate and persistent winds from the west, dry atmosphere, slightly dry soils	51	>2.0μm	71.3	14.7	0.0
			<2.0μm	9.8	3.5	0.8 (S-rich)
09/16/77	Light and variable winds, moist atmosphere, extremely dry soils	111	>2.0μm	72.4	14.3	neg (metals)
			<2.0μm	10.9	2.4	0.0
04/24/76	Moderate and persistent winds from the west, dry atmosphere, slightly dry soils	115	>2.0μm	79.2	15.0	neg (salt)
			<2.0μm	4.6	1.2	0.0
Arithmetic mean[b]		125	>2.0μm	75.3	15.1	neg
			<2.0μm	8.0	1.6	neg

[a] Stockton climatological data used.

[b] Particle size data represent a weighted mean.

TABLE 4-8. SUMMARY OF WOODLAND MICROSCOPY ANALYSES

Date	Meteorological conditions[a]	TSP, $\mu g/m^3$	Percent contribution			
				Mineral	Carbonaceous	Other[b]
03/01/76	Strong and persistent winds from the south, slightly dry atmosphere, moist soils, probably post-frontal passage of maritime air	15	>2.0µm	32.5	38.3	neg (metals and salts)
			<2.0µm	20.5	8.8	0.0
05/01/77	Moderate and persistent winds from the south, moist atmosphere, moist soil, thunderstorms during the day	17	>2.0um	19.7	38.7	neg (metals and salts)
			<2.0µm	33.1	8.4	0.0
11/02/76	Very light and variable winds, dry atmosphere, very dry soils, probably inversion condition	277	>2.0µm	69.9	14.3	neg (metals and fly ash)
			<2.0µm	11.9	3.9	0.0
05/18/76	Strong and persistent winds from the south, very dry atmosphere, very dry soils	87	>2.0µm	46.2	14.2	neg (metals)
			<2.0µm	36.2	3.3	neg (metals)
05/06/76	Moderate but variable winds, very dry atmosphere, dry soil, probably inversion condition	202	>2.0µm	79.6	8.1	neg (metals)
			<2.0µm	10.3	2.0	0.0
11/03/77	Moderate and persistent winds from the south, dry atmosphere, very dry soils, smoke in valley, subsidence inversion condition likely	76	>2.0µm	59.0	25.3	neg (metals)
			<2.0µm	11.6	4.1	0.0
Arithmetic mean[c]		112	>2.0µm	66.6	14.9	neg
			<2.0µm	15.3	3.5	neg

[a] Sacramento climatological data used.

[b] CuZn particulates were observed in every sample.

[c] Particle size data represent a weighted mean.

TABLE 4-9. SUMMARY OF LIVE OAK MICROSCOPY ANALYSES

Date	Meteorological conditions[a]	TSP, $\mu g/m^3$	Percent contribution			
				Mineral	Carbonaceous	Other
11/02/76	Light and variable winds, dry atmosphere, dry soils, smoke and haze, probable inversion condition	242	>2.0μm	77.8	12.9	0.0
			<2.0μm	7.5	1.8	neg (metals and fly ash)
10/15/76	Same as 11/02/76	233	>2.0μm	85.1	8.9	neg (metals)
			<2.0μm	5.5	0.5	0.0
08/04/76	Moderate and persistent winds from the south, dry atmosphere, very dry soils	88	>2.0μm	46.2	43.9	neg (metals)
			<2.0μm	5.9	4.0	0.0
12/23/77	Moderate and persistent south winds, moist atmosphere and soil, storm system in area	21	>2.0μm	96.8	2.9	0.0
			<2.0μm	neg	0.3	0.0
10/03/76	Moderate and persistent winds from the NW, dry atmosphere, dry soils, fog and smoke, possible inversion condition	101	>2.0μm	83.9	15.2	neg (metals)
			<2.0μm	0.5	0.3	0.0
06/18/77	Moderate and persistent winds from the south, moderately dry atmosphere, dry soils, smoke and haze	104	>2.0μm	90.7	2.0	neg (fly ash)
			<2.0μm	6.9	0.4	
Arithmetic mean[b]		132	>2.0μm	79.4	13.8	neg
			<2.0μm	5.6	1.2	neg

[a] Sacramento climatological data used.
[b] Particle size data represent a weighted mean.

TABLE 4-10. SUMMARY OF CHICO MICROSCOPY ANALYSES

Data	Meteorological conditions[a]	TSP, μg/m^3	Percent contribution			
				Mineral	Carbonaceous	Other
01/13/76	Relatively moist air, northerly winds, slightly dry soils, indicative of maritime frontal passage	74	>2.0μm	54.7	12.0	0.0
			<2.0μm	32.0	1.4	0.0
11/08/76	Light and variable winds, very dry atmosphere, very dry soils, probably subsidence inversion condition	163	>2.0μm	73.5	8.3	0.0
			<2.0μm	17.6	0.6	0.0
05/01/77	Moderate southerly winds, moist air, moist soils, indicative of Pacific storm	18	>2.0μm	40.9	13.3	0.0
			<2.0μm	45.0	0.8	0.0
06/18/77	Moderate winds, dry atmosphere, moist soils, post-frontal passage condition	72	>2.0μm	16.5	9.9	0.0
			<2.0μm	72.7	0.8	0.0
09/18/77	Strong winds, moist atmosphere, moist soils, storm system condition	22	>2.0μm	84.0	5.2	0.0
			<2.0μm	3.7	7.1	0.0
10/22/77	Light and variable winds, relatively dry atmosphere, dry soils, probable inversion condition	134	>2.0μm	66.1	16.5	neg (metals)
			<2.0μm	16.4	1.0	neg (metals)
Arithmetic mean[b]		81	>2.0μm	59.3	11.4	neg
			<2.0μm	28.1	1.2	neg

[a] Red Bluff climatological data used.

[b] Particle size data represent a weighted mean.

treatment are required to resuspend particles. In this case, a resistant organic material, probably a polymer, formed on all filters and made particulate removal most difficult. The observed large C particles may be a result of entrapment during collection or of DRI procedures, which might have broken up the polymer. Regardless of this uncertainty, it is obvious that there is a large source of carbonaceous material in the San Joaquin Valley south of Modesto and that its source is neither biological nor automotive. Large amounts of carbon were noted even when crop burning was reported to be light. Perhaps the process involves long- and short-range transport of volatile organic material and subsequent condensation/polymerization upon collection. If any future special study sampling is conducted, it would be most beneficial to collect samples by low volume sampling on thin film membranes and to sample potential sources simultaneously.

Mineral particles were by far the largest contributor to the particulate material observed; however, there was no indication that fugitive minerals could be distinguished from natural mineral emissions. Most minerals had the elemental composition of clays. Moderate amounts of quartz, some Ca-rich minerals, including CaS, and small amounts of feldspars were observed. The gypsum ($CaSO_4 \cdot 2H_2O$) component was never observed to be large enough to produce high S levels. Thus, most S noted would be $SO_4^=$ and not mineral.

SECTION 5

CHEMICAL/ELEMENTAL ANALYSIS OF HISTORICAL HI VOL FILTERS

INTRODUCTION

Most hi vol filters are routinely analyzed only for total mass. Unfortunately, the information provided by such analyses is of very limited utility. As the material presented in Section 3 adequately demonstrates, it is very difficult to quantify source contributions to measured TSP values without having access to further information. One class of information that can prove extremely powerful is data concerning the chemical and elemental concentrations present on loaded filters. Properly analyzed, such data can be combined with TSP, meteorological, and emission data to refine source contribution estimates.

This section presents the theoretical concepts that were used to guide subsequent investigations, briefly describes the laboratory techniques that were used to analyze the filters, summarizes the data that were generated, and discusses the results of statistical techniques (such as correlation analysis and factor analysis) that were used to analyze the data. Finally, judgments are rendered as to the nature and magnitude of the sources contributing to measured TSP values.

THEORETICAL CONCEPTS

Certain elements are uniquely associated with certain types of emission sources and can be used to trace the impact of those sources. As S. K. Friedlander stated in a pioneer work in this field, "a basic assumption...is that each type of source (automobile, power plant, ocean, and so on) emits a characteristic series of elements. The concentrations of this set of elements can be looked upon as the frequency of appearance of the alphabet of which each emission is composed."[1] This is a very important concept; it is fundamental to the information presented in the remainder of this section.

Table 5-1 identifies the elemental concentrations that reportedly are associated with various source types. It should be noted that these values are presented only as indicators of the relative magnitudes of elemental concentrations. Concentrations in auto exhaust can, for example, vary significantly depending upon the percent of traffic which is diesel-powered,

TABLE 5-1. RELATIVE ELEMENTAL CONCENTRATIONS BY SOURCE TYPE

Element	San Joaquin Valley soils	Marine[b]	Fuel oil	Auto	Tire wear[c]	Agricultural burning	Fertilizer[d]
Al	1.00(4.83%)	e	.17	.02	e	3.11	f
Mg	.117	.067	f	f	e	f	f
P	.01[b]	e	f	f	e	f	1.00(11.0%)
S	.083	.046	.50	.25	e	e	f
K	.311	.021	.70	e	e	1.00(3.6%)	.604
Ti	.043	e	.013	e	e	.45	f
V	.0017	e	1.00(2.0%)[a]	e	e	.111	f
Cr	.011	e	f	e	e	f	f
Mn	.0093	e	.013	e	e	.111	f
Fe	.646	e	4.9	.169	e	1.77	f
Co	e	e	1.55	f	e	f	f
Ni	.0008	e	3.75	e	e	e	f
Cu	.015	e	f	f	e	f	f
Zn	.006	e	e	.03	1.00(2.0%)	f	f
Br	.0002	.0035	e	.366	e	.02	f
Pb	.0002	e	.015	1.00(15.1%)[a]	e	e	f
Cl	.002	1.00(55.4%)[a]	e	.167	e	1.89	f
Na	.062	.557	1.07	e	e	2.77	f
Ca	.414	.021	.28	e	e	e	f
Si	3.298	.00015	4.10	.0017	e	e	f
C	f	e	e	f	43.65	f	f

[a] Leach, J. T., G. T. Bates, and L. Stanfield. San Joaquin Valley Particulate Matter Study. Unpublished.

[b] Rahn, K. A. The Chemical Composition of the Atmospheric Aerosol. University of Rhode Island, Kingston, Rhode Island. July 1976. [Wedepohl (1971) presented in Rahn.]

[c] Reference 1.

[d] Fertilizing Materials Tonnage Report: October-November-December 1978. California Department of Food and Agriculture, Sacramento, California

[e] Negligible concentrations.

[f] Unknown.

equipped with catalytic convertors (hence burning unleaded gas), or powered by fuel with special additives.

The key messages conveyed by the data in Table 5-1 are the following.

- Si, Al, Mg, Ti, K, Mn, Ca, and Fe are a set of elements which can be used as indicators of windblown and fugitive dust (soil related). Coal burning releases the same set of elements, but the lack of coal burning in the central valleys eliminates this as a potential source. Large quantities of Al can be emitted by such industrial sources as an aluminum reduction plant. The presence of such sources can be inferred from the dissociation of Al from the soil group pattern. Similarly, Ca is emitted in large quantities by cement plants; significant amounts of S are present in gypsum.
- A tracer for fuel oil combustion is V. Crude oil combustion associated with tertiary oil recovery in Kern County emits significant quantities of V, S, Ni, and Fe.
- Distinct tracers for automobile exhaust are Br and Pb. Depending upon emission controls and fuel additives, Cl, S, and P may also form part of the auto exhaust group.
- A unique tracer of tire wear is Zn.
- Tracers of either sea salt or agricultural burning are Na and Cl. Where both sources are present, meteorological conditions and agricultural burning data can be reviewed to assess which of the two sources accounts for the observed Na/Cl pattern.
- P can be used as a tracer of fertilizer application. Where P is used as a gasoline additive, the utility of P as a fertilizer tracer becomes limited.
- Cr, Cu, and Co can be used to identify unique industrial sources. However, Cu poses a problem, insofar as hi vol sampler motors tend to be sources of that element.[2]

Two other concepts can be applied to the data presented. First, the ratio of Br to Pb can be used to measure the degree to which the TSP aerosol is fresh or aged. A high ratio suggests that the hi vol sampler is being exposed to an aerosol emitted by a nearby roadway. Second, $S/SO_4^=$ relationships can be investigated to identify sources of measured $SO_4^=$ concentrations. The ratio of S to $SO_4^=$ can be used to indicate the degree to which $SO_4^=$ is mineral in origin. A S/$SO_4^=$ ratio of ∿0.35 implies that all of the $SO_4^=$ is water soluble (or secondary $SO_4^=$) and, since gypsum ($CaSO_4 \cdot 2H_2O$) is the only major sulfate which is not water soluble, a ratio approaching unity implies that most of the $SO_4^=$ is mineral. The correlation between S and $SO_4^=$ can be used to infer the source complexity of the $SO_4^=$. A strong correlation implies that there is a single dominant source of both the S and the $SO_4^=$, whereas a weak correlation implies a multitude of sources. In addition, the factor loadings for S (see the subsection on factor analysis) can be used to determine the percent of variance in S that is explained by soil, automotive, fuel oil, and other factors.

LABORATORY METHODOLOGY

Twenty-four filters from each of the eight Phase I sites and six Phase II sites were solicited from ARB according to the design specified in Section 2. Upon receipt, the filters were logged in and assigned a sample number. Two strips (10 in. long) were cut from each filter, one for $SO_4^=$ analysis (3/4 in. wide) and the other for BSO analysis (1-1/2 in. wide). It was originally intended that NO_3^- analysis would also be performed, but research performed by the contractor after the study design was prepared indicated that problems of artifact formation and NO_3^- decay on the filters were potentially so severe as to render such analysis fruitless. In addition, a portion of each filter was properly labeled and delivered to Monsanto for elemental analysis.

The $SO_4^=$ strip was put in a screw cap jar and 50 ml of deionized H_2O were added. The jar was capped, the filter extracted in an ultrasonic bath for 15 minutes, and the solution allowed to stand overnight. The solution was then filtered through Whatman #40 paper and analyzed for $SO_4^=$. The barium sulfate turbidimetric test, using Hach Chemical Company Sulfaver IV powder, was made; primary standard grade ammonium sulfate was the standardization material.

The BSO strip was put in a Whatman paper extraction thimble and weighed. The thimble and filter were extracted with benzene for 8 hours in Soxhlet apparatus. The thimble and filter were dried in a hood, then in a forced air oven at 105°C, cooled, and reweighed. The calculations were as follows:

Total mg $SO_4^=$ per filter = (mg/l $SO_4^=$)(.05 l)(9.33)

Total mg BSO per filter = (mg loss on extraction)(4.67)

The factors 9.33 and 4.67 are the ratios of the width of the filter strip used to the exposed part (7 in. wide) of the filters.

Blank filters, when available, were analyzed and the background values subtracted. The total mg, times 1000, divided by the air volume in m^3, gives the $\mu g/m^3$ concentration of the material of interest.

Monsanto was provided enough filter material so that they could analyze a 1-1/2 in. diameter spot with an EDAX International EXAM System which utilizes an X-ray fluorescence (XRF) technique.

X-ray fluourescence is based upon the principle that each element emits characteristic X-ray lines when it is excited by high energy particles. The resulting lines are measured by energy sensitive detectors to determine the wavelengths and intensities of the emitted X-rays. The wavelength is used to identify the element, and intensity, being directly proportional to $\mu g/cm^2$, is used to measure concentrations.

There are a number of persuasive advantages associated with XRF, but those advantages do not come without a cost. Among the advantages are its multiple element capability, high sensitivity for elements of interest, ease of automation, stability of calibration, and relatively low cost per sample.[3] Major disadvantages include the following: XRF tends to provide poor resolution for elements above Mg on the periodic table; X-ray emissions tend to vary in relation to the nature and quantity of other elements present (matrix effect); and blank filter impurities can yield erroneous results.[4,5,6] Other methods, primarily atomic absorption spectrometry, were considered but discarded due to their high costs and inability to provide data on certain elements of interest (e.g., S).

The first of the three aforementioned disadvantages was eliminated by not analyzing for any elements above Mg. The adverse impact of the second was minimized by simulating a matrix with calibration standards. The last was addressed by obtaining representative blank filters whenever possible, analyzing them with the XRF System, and subtracting the resulting concentrations from loaded filter concentrations.

The XRF analysis was performed for 17 elements: Al, Mg, P, S, K, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Br, Pb, and Cl. The following conditions were used on the EDAX International EXAM System for elements Al, Mg, P, S, K, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Br, and Pb:

X-ray target material	Rhodium
Tube voltage	20 kV
Tube current	64 μA
Energy range	0-20 at 50 eV/channel
Counting time	100 s

The following conditions were used for the element Cl:

X-ray target material	Tungsten
Tube voltage	10 kV
Tube current	500 μA
Energy range	0-8 at 20 eV/channel
Counting time	100 s

Quantification, in units of $\mu g/cm^2$, was obtained by using calibration standards purchased from Columbia Scientific Industries. The XRF line interferences were negligible except in the case of Co for which a correction was made. Corrections for substrate self-absorption, particle size effects, etc. were not made since they would have entailed many more measurements and lengthy calculation. Minimum detectable concentrations were 1.0 $\mu g/cm^2$ for Co and 0.1 $\mu g/cm^2$ for all other elements. These values are equivalent, at an assumed hi vol sample flow rate of 2000 m^3, to 0.23 and 0.02 $\mu g/m^3$. Whenever concentrations were observed to be below these minimum detectable limits, one-half of these values (i.e., 0.12 and 0.01 $\mu g/m^3$) were used in subsequent statistical analyses. Blank filter concentrations obtained from four filter lots that were analyzed are as shown in Table 5-2.

Replicate sulfate and elemental analyses were performed on $\sim$7.5 percent of the filters. The initial and replicate sample concentrations for a given species and a given filter were averaged and the standard deviation computed. A coefficient of variance (CV), equal to the standard deviation of two analyses divided by their mean, was then computed. The average CV computed for each species is presented in Table 5-3. Most of the variation can be attributed to nonuniform deposition of material on the filter surface or, in the case of the elements, spectral attenuation and interference.

The study design originally assumed that BSO analyses would adequately indicate the amount and variability of organic particulate matter at the various sites. Phase I analyses showed quite conclusively, however, that BSO were reacting on the filters over time and causing negligible concentrations to be measured. Microscopy results from DRI, which showed large amounts of carbonaceous materials, led to a decision to attempt to define total C concentrations on selected filters.

The laboratory procedure involved conversion of C containing compounds to CO_2. This conversion occurred when individual

TABLE 5-2. BLANK FILTER CONCENTRATIONS[a]

($\mu g/cm^2$)

	Lot number				
Chemical/element	8233[b]	8243[c]	8252[d]	Unknown[e]	Average
Mg	0.4	0.3	0.9	0.5	0.53
P	3.0	1.8	1.6	3.1	2.38
S	-	-	-	0.9	≯0.30
K	0.6	0.4	0.3	-	≯0.35
V	0.2	-	0.1	-	≯0.13
Cr	0.2	0.2	-	-	≯0.15
Mn	0.1	0.2	-	-	≯0.13
Fe	-	0.2	-	-	≯0.13
Cu	-	-	0.1	-	≯0.10
All other elements	-	-	-	-	≮0.10
$SO_4^=$	0.6	0.7	0.5	-	≯0.48

[a] Data represent the average of analyses for 2 filters for elements and 3 filters for $SO_4^=$.

[b] Representative of filters within the following ranges: 031136-031720, 070591-074490, and 074556-075270.

[c] Representative of filters within the following range: 343721-348270.

[d] Representative of filters within the following ranges: 100001-103120, 103511-103965, 104161-104355, 105526-106045, 106631-106695, 106761-106825, 106956-107029, and 107216-110465.

[e] Representative of filters near 00600.

TABLE 5-3. COEFFICIENTS OF VARIANCE FOR REPLICATE FILTER ANALYSES[a]

Variable	Coefficient of variance
Al	.219
Mg	.301
P	.222
S	.114
K	.234
Ti	.205
V	.219
Cr	.207
Mn	.171
Fe	.185
Co	-
Ni	.367
Cu	.452
Zn	.083
Br	.444
Pb	.374
Cl	.526
$SO_4^=$	.196[b]

[a] Based on 26 replicate analyses except where otherwise noted.
[b] Based on 19 replicate analyses.

samples were heated to 800°C in a pure oxygen atmosphere; the CO_2 was then measured with a gas chromatograph/mass spectrometer. Specific steps were as follows:

- A measured portion of the filter was cut out.
- The cut portion was placed in a porcelain boat and inserted into a glass tube, which was subsequently heated to 800°C by a tube furnace.
- The inlet of the glass tube was connected to a tank of 99.99 percent pure oxygen; the outlet was connected to a stainless steel coil, which air cooled the hot gas stream. The outlet gas stream was connected to a tedlar bag. Oxygen was pumped through the tube at the rate of 2 l/min for 3 minutes, after an initial heating period of 3 minutes.
- A 0.5 cc aliquot of gas was removed from the tedlar bag, using a gas-tight syringe, and was analyzed for CO_2.
- Analysis of the gas sample was performed on a Hewlett-Packard Model 5992 GC-MS that was set to monitor mass 44 (the molecular weight of CO_2). This allowed specific and sensitive detection down to 1.0 ppm. Instrumental conditions were as follows:

  Column - 6 ft x 0.083 in. ID nickel column packed with Chromosorb 101

  Column temperature - 60°C isothermal

  Injector temperature - 140°C

  Carrier gas - helium, flow rate of 20 cc/min
- Standards of CO_2 gas were analyzed under the same instrumental conditions and were used to quantify the CO_2 observed in the samples.
- All samples were analyzed in duplicate to provide a more representative number for the CO_2 concentration.

OBSERVED SPECIES CONCENTRATIONS

As Section 2 documents, the modified study design called for the selection and analysis of identical sets of filters from each of the eight Phase I and six Phase II sites. Thus, 24 filters were to be analyzed with 6 being drawn from each of the four quarters of the July 1, 1977-June 30, 1978 period. In this way, data from one site could be directly compared with that for the other special study sites.

This design proved impossible to implement completely. As Table 5-4 indicates, there is substantial conformity from one site to another but there are only two days when filters were available from all 14 of the special study sites. This fact required that some caution be exercised in making comparisons among sites. The data are, however, well distributed temporally. Thus, with the exception of Chico and possibly Fort Bragg, the data analysis for any given site can be considered representative of conditions existing at that site from mid-1977 to mid-1978. Filters were not available for the fourth quarter at Chico, necessitating some care in interpreting data from that site.

Average chemical/elemental concentrations for the 14 special study sites are given in Table 5-5. Individual sample concentrations and standard deviations are provided in Appendix C. Although 24 filters were obtained for each site, not all of the data produced by analysis of these filters was used to compute the averages given in that table.

Eight of the Bakersfield (Flower), 5 of the Taft, and 3 of the Visalia filters were provided without data concerning the chemical/elemental concentrations of the unexposed filters. As a result, and in accord with the information presented previously in this section, $SO_4^=$, BSO, and P concentrations were not calculated for those filters. Similarly, representative blank filters were not available for any of the Fresno (Cal State) and Parlier filters or for 19 of the Kern Refuge filters. The Fresno County Air Pollution Control Division provided blank filter $SO_4^=$ and BSO concentrations for 22 of the filters provided for Fresno (Cal State) and Parlier. The remaining 2 filters were analyzed elementally but are not included in the means given in Table 5-5. With the exception of 5 filters from Kern Refuge, measurements of P were not made for any of the filters from Fresno (Cal State), Parlier, or Kern Refuge. One of the filters from Merced was provided without flow rate informaton. This filter was not included in the reported means. Two filters were excluded from the Modesto (J St) means, one because blank filter data were not available and the other because there was insufficient filter material for $SO_4^=$/BSO analysis. Three filters were excluded from the Woodland means, 2 because blank filter data were not available and 1 because there was not a sufficient amount of filter material with which to perform chemical analyses. Two other filters from that site were not available. Two filters from Live Oak were not analyzed due to procedural problems in the laboratory. Lastly, 4 of the Fort Bragg filters were unaccountably misplaced in transit.

TABLE 5-4. DAYS FOR WHICH FILTERS WERE ANALYZED[a]

Date	Bakersfield (Flower)	Taft	Kern Refuge	Visalia	Parlier	Fresno (Cal State)	Five Points	Merced	Modesto (J St)	Woodland	Live Oak	Chico	Fort Bragg	Paso Robles
1977 7/6	x	x	x	x	x	x	x		x	x	x	x		x
7/18	x	x	x	x	x	x	x	x	x	x	x	x	x	x
7/24											x	x		
7/30								x						
8/5														x
8/10		x												
8/11	x		x	x	x	x	x	x	x	x	x	x	x	
8/17		x	x									x	x	
8/23				x			x	x	x	x	x			x
8/24	x													
8/29	x				x									
9/4	x	x	x	x	x	x	x	x	x	x	x	x		x
9/10													x	
9/16												x		
9/22											x	x		
9/27		x												
9/28	x(7)	x(7)	x(5)	x(6)	x(6)	x(5)	x(6)	x(6)	x(6)	x(6)	x(8)	(8)	x(5)	x(6)
10/4												x		
10/9		x												
10/10			x	x	x	x	x	x	x	x	x	x		
10/16	x												x	
10/22	x		x	x	x	x	x	x	x	x	x	x		x
10/28		x				x								
11/3											x	x		x
11/9	x	x	x	x	x		x	x	x	x	x	x		
11/27	x	x	x	x	x	x	x	x	x	x	x	x	x	x
12/3					x									
12/9	x	x	x	x		x	x	x	x	x	x	x		x
12/15					x				x					
12/27	x	x	x	x		x	x	x		x		x		x
12/28				x										
12/30	(6)	(6)	(6)	(7)	(6)	(6)	(6)	(6)	(6)	(6)	x(7)	(8)	(2)	(5)
1978 1/2							x						x	
1/3	x	x												
1/4				x										
1/8			x		x	x		x	x	x	x	x		x
1/20			x											x
1/25		x												
1/26	x			x	x		x	x	x	x		x	x	
2/1											x	x	x	
2/7	x			x		x	x	x	x	x		x		x
2/13		x										x		
2/14			x											
2/25					x	x							x	
3/2		x												
3/3	x		x	x	x	x	x			x		x	x	x
3/9								x	x				x	
3/15	x		x		x	x	x	x	x	x		x	x	x
3/17		x												
3/21				x					x		x		x	
3/27	x		x	x	x	x	x	x		x	x	x		x
3/28	x(7)	(5)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(4)	(8)	(8)	(6)
4/2	x								x					
4/8								x						
4/14	x	x		x	x					x				x
4/20	x	x		x	x	x	x	x	x	x				x
4/27			x											
5/2		x	x	x	x	x	x		x	x	x			
5/3	x													
5/8	x		x											
5/9		x												
5/10											x			
5/14	x				x	x	x	x	x	x	x			x
6/1					x									
6/7			x	x	x		x	x	x	x	x		x	
6/9		x												
6/13						x							x	x
6/14			x	x										
6/19	x	x		x		x	x	x	x	x			x	x
6/21	(7)	(6)	(5)	(6)	x(7)	(5)	(5)	(5)	(6)	(6)	(4)	(0)	(3)	(5)

[a] The number of days represented in each quarter is given in parenthesis.

TABLE 5-5. AVERAGE CONCENTRATIONS

	No. of sam- ples	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	Sum of ele- ments	$SO_4^=$	TSP
Bakersfield	24	1.62	2.37	a	5.76	1.57	.15	.07	.17	.22	3.47	<.12	.14	.35	.04	.22	1.35	.07	a	a	139.58
(Flower)	16	1.68	2.42	.93	5.62	1.61	.15	.07	.18	.23	3.58	<.12	.15	.36	.02	.21	1.27	.10	18.60	10.61	147.38
Taft	20	1.14	1.72	.89	4.04	1.33	.11	.03	.16	.26	2.67	<.12	.10	.06	<.01	.03	.22	.06	12.82	7.52	98.75
Kern Refuge	23	.96	1.80	a	2.83	1.07	.11	.04	.11	.23	1.82	<.12	.05	.13	.23	.02	.06	<.01	9.46	a	91.13
Visalia	21	1.75	1.61	.41	2.89	2.13	.17	.02	.17	.25	3.80	<.12	.09	.25	<.01	.08	.57	.21	14.53	4.21	109.62
Parlier	22	1.84	2.89	a	2.73	1.37	.12	.07	.19	.27	2.68	<.12	.07	.10	<.01	.04	.20	.07	12.74	6.67	124.73
Fresno (Cal State)	22	1.80	2.47	a	2.57	1.35	.14	.08	.18	.26	2.92	<.12	.06	.09	<.01	.11	.85	.07	13.05	4.10	101.95
Five Points	24	1.20	1.23	.47	2.18	1.58	.14	.02	.14	.31	2.84	<.12	.07	.11	<.01	<.01	<.01	.18	10.47	5.25	112.46
Merced	23	.99	1.42	.40	3.06	1.47	.16	.10	.26	.27	2.74	<.12	.06	.11	<.01	.09	.57	.10	11.90	3.75	77.87
Modesto (J St)	22	1.18	1.17	.32	3.00	1.25	.17	.08	.17	.20	2.28	<.12	.06	.10	<.01	.07	.61	.08	10.84	4.55	103.55
Woodland	21	1.00	1.24	.44	1.29	.98	.12	.06	.20	.25	2.66	<.12	.05	.14	<.01	.03	.12	.27	8.98	2.56	72.67
Live Oak	22	1.34	2.39	.36	1.14	1.21	.18	.08	.27	.32	3.28	.14	.06	.16	.01	.03	.09	.01	11.13	2.81	85.73
Chico	24	.99	2.26	.46	1.96	.70	.14	.07	.22	.25	2.77	<.12	.04	.07	.01	.15	.55	.03	10.80	1.90	77.96
Fort Bragg	19	.59	.42	.51	.70	.30	.02	.03	.02	.07	.45	<.12	.02	.07	<.01	.01	.04	2.63	5.88	a	76.63
Paso Robles	24	.46	.34	.56	2.51	.38	.03	.01	.03	.09	.80	<.12	.03	.06	<.01	.04	.15	.31	5.80	4.67	76.63
Ratio of highest to lowest		4.0	8.5	2.9	8.2	5.4	9.0	10.0	13.5	4.6	8.0	1.2	7.5	6.0	23.0	22.0	135.0	263.0	3.2	5.6	2.0

[a] Data not available.

Enclosed values represent the highest value observed.

Enclosed values represent the lowest value observed.

Recognizing that there are some statistical problems associated with comparing data from these sites with one another, a number of distinct characteristics of these data can be noted. The largest ratios between lowest and highest concentrations are for Br, Pb, Cl, and Zn. The Br and Pb ratios are clearly indicative of the difference between rural and traffic-impacted sites, whereas the Cl ratio is a function of the extremely high concentrations recorded at Fort Bragg, which is adjacent to the Pacific Ocean. There is reason to suspect that the Zn ratio may be a function of blank filter interference.

Bakersfield (Flower) is characterized by relatively high concentrations of P, S, Ni, Cu, Br, Pb, $SO_4^=$, TSP, K, Fe, Zn, and Mg; Taft by high concentrations of P, S, Ni, $SO_4^=$, and TSP, and by low Cu concentrations; Kern Refuge by high Zn concentrations (most probably a function of filter interference) and relatively low concentrations of Al, Ti, Cr, Fe, Br, Pb, and Cl; Visalia by high concentrations of K, Fe, Ti, Cu, Al, and Ni and by low concentrations of P and V; and Parlier by high concentrations of Al, Mg, TSP, Mn, and $SO_4^=$. Similarly, Fresno (Cal State) is characterized by relatively high concentrations of Al, Mg, V, Pb, and Br; Five Points by high values for Mn, K, and TSP and by low values for V, Br, and Pb; Merced by high concentrations of V, Cr, Mn, and S and by low values for P; Modesto (J St) by high values for Ti, V, and Pb and by low concentrations of Mg and Mn; and Woodland by high Cl concentrations but low values of S, $SO_4^=$, and TSP. Live Oak is distinctive in that it shows high Ti, Cr, Mn, V, Fe, Cu, and Zn concentrations along with low concentrations of P, S, Cl, and $SO_4^=$. Chico is notable for high Br, Cr, and Zn values and low K, Ni, Cu, Cl, and $SO_4^=$ concentrations. Fort Bragg and Paso Robles have the lowest concentrations of virtually every species and are notable only for high Cl concentrations.

Table 5-6 presents the same chemical/elemental data for the 14 study sites in a slightly different way. Now expressed as a percent of TSP, these values are still essentially the same as those presented in Table 5-5. Both the Ba/Pb and $S/SO_4^=$ ratios are presented in Table 5-6. According to these data, Live Oak, Parlier, Five Points, and Woodland appear to be impacted primarily by secondary $SO_4^=$, and Chico primarily by mineral $SO_4^=$. Only 6 of the 14 sites measured significant amounts of Pb. Of these, Chico shows the highest Br/Pb ratio (0.23), indicating that it is impacted by a fresh aerosol. The other 5 sites (Bakersfield, Merced, Visalia, Fresno, and Modesto) have Br/Pb ratios ranging from 0.17 to 0.12, indicating that these sites are not so heavily impacted by fresh auto exhaust.

A summary of total C analyses is given in Table 5-7. Three filters were analyzed from each of seven Phase I sites. Every other available filter (12) was analyzed for Fresno (Cal State). Two major facts emerge from all of these C data: first, total C

TABLE 5-6. AVERAGE CONCENTRATION, PERCENT OF TSP

	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	$S/SO_4^=$	Br/Pb	Elem/ TSP (100)
Bakersfield[a]	1.16	1.70	b	4.13	1.12	.11	.05	.12	.16	2.49	<.09	.10	.25	.03	.16	.97	.05	b	b	.16	b
(Flower)[c]	1.14	1.64	.63	3.81	1.09	.10	.05	.12	.16	2.43	<.09	.10	.24	.01	.14	.86	.07	7.20	.53	.17	12.6
Taft	1.15	1.74	.90	4.09	1.35	.11	.03	.16	.26	2.70	<.12	.10	.06	<.01	.03	.22	.06	7.62	.54	.14	13.0
Kern Refuge	1.05	1.98	b	3.11	1.17	.12	.04	.12	.25	2.00	<.13	.05	.14	.25	.02	.07	.01	b	b	.33	10.4
Visalia	1.60	1.47	.37	2.64	1.94	.16	.02	.16	.23	3.47	<.11	.08	.23	<.01	.07	.52	.19	3.84	.69	.14	13.3
Parlier	1.48	2.32	b	2.19	1.10	.09	.06	.16	.22	2.15	<.10	.06	.08	<.01	.03	.16	.05	5.35	.41	.21	10.1
Fresno (Cal State)	1.77	2.42	b	2.52	1.33	.13	.08	.18	.25	2.86	<.12	.06	.09	<.01	.11	.83	.07	4.02	.63	.13	12.7
Five Points	1.07	1.09	.42	1.94	1.40	.12	.02	.12	.28	2.53	<.11	.06	.10	<.01	<.01	<.01	.16	4.67	.42	1.00	9.3
Merced	1.27	1.82	.52	3.92	1.88	.20	.12	.33	.35	3.52	<.15	.07	.14	<.01	.12	.73	.12	4.82	.81	.16	15.2
Modesto (J St)	1.14	1.13	.31	2.90	1.21	.16	.08	.16	.19	2.20	<.12	.06	.10	<.01	.07	.59	.08	4.39	.66	.12	10.4
Woodland	1.37	1.70	.61	1.78	1.34	.17	.08	.27	.35	3.66	<.17	.06	.19	<.01	.05	.16	.37	3.53	.50	.28	12.2
Live Oak	1.56	2.79	.42	1.33	1.41	.21	.09	.32	.38	3.82	.16	.06	.19	.02	.04	.10	.01	3.28	.41	.35	12.8
Chico	1.27	2.90	.59	2.51	.90	.18	.09	.28	.32	3.55	.15	.05	.09	.01	.19	.71	.04	2.44	1.03	.27	13.7
Fort Bragg	.77	.55	.67	.91	.39	.03	.04	.03	.09	.59	<.16	.03	.09	<.01	.01	.05	3.43	b	b	.25	7.7
Paso Robles	.60	.44	.73	3.28	.50	.04	.01	.04	.12	1.04	<.16	.04	.08	<.01	.05	.20	.40	6.09	.54	.27	7.6
Ratio of highest to lowest	3.0	6.6	2.9	4.5	5.0	7.0	12.0	11.0	4.2	6.5	1.4	3.3	4.2	25.0	19.0	97.0	343.0	3.1			2.0

[a] 24 samples.
[b] Data not available.
[c] 16 samples.
Enclosed values represent the highest value observed.
Enclosed values represent the lowest value observed.

TABLE 5-7. SUMMARY OF TOTAL CARBON ANALYSES

Site	Date	TSP conc, μg/m^3	C conc, μg/m^3	TSP, %	Site avg % TSP[a]
Bakersfield (Flower)[b]	10/22/77	194	11.46	5.9	5.6
	3/15/78	161	9.69	6.0	
	5/14/78	140	6.68	4.8	
Parlier	8/11/77	190	4.69	2.5	3.5
	1/26/78	82	6.62	8.1	
	5/02/78	116	2.14	1.8	
Fresno (Cal State)[c]	7/18/77	98	2.90	3.0	4.8
	8/29/77	73	6.77	9.3	
	9/28/77	125	4.52	3.6	
	10/22/77	203	11.25	5.5	
	11/27/77	171	12.29	7.2	
	12/27/77	30	2.71	9.0	
	2/07/78	33	3.49	10.6	
	3/03/78	26	0.72	2.8	
	3/27/78	72	1.82	2.5	
	4/20/78	30	0.92	3.1	
	5/14/78	98	1.32	1.3	
	6/19/78	128	3.32	2.6	
Merced	8/11/77	104	5.35	5.1	7.2
	10/22/77	191	15.18	7.9	
	4/08/78	56	4.78	8.5	
Modesto (J St)	10/22/77	210	13.38	6.4	5.0
	1/08/78	54	1.04	1.9	
	6/07/78	88	3.16	3.6	
Woodland	9/04/77	76	2.86	3.8	5.5
	10/22/77	150	10.00	6.7	
	5/02/78	54	2.57	4.8	
Live Oak	9/22/77	56	2.85	5.1	6.0
	12/09/77	115	10.04	8.7	
	5/02/78	65	1.32	2.0	
Chico	7/18/77	99	2.29	2.3	3.7
	10/10/77	82	4.09	5.0	
	3/15/78	72	2.93	4.1	

[a] Reflects a weighted average.

[b] Linear regression analysis for all sites yields: $TSP = 1.12C + 94.3$, $r = +0.47$ ($n = 33$).

[c] Linear regression analysis for Fresno yields: $TSP = 11.9C + 39.1$, $r = +0.79$ ($n = 12$).

concentrations are highest during the late fall and early winter when inversion and TSP conditions tend to be most severe; second, total C fractions of TSP are relatively high, ranging from ~3 to 7 percent. Since total C reportedly constitutes one-half of all atmospheric carbonaceous material, this suggests that the carbonaceous fraction is ~6 to 14 percent of the measured TSP.[7] Given the small number of samples that were analyzed, these data were not subjected to the statistical analyses discussed in the remainder of this section.

Viewed in perspective, the most important facts to emerge from these new data are that soil elements seem to contribute significant TSP fractions at all of the sites; that soil elements, plus Cr and Cl, contribute relatively larger TSP fractions in the Sacramento Valley than they do in the San Joaquin Valley; that S, $SO_4^{=}$, and Pb contribute relatively larger TSP fractions in the San Joaquin Valley than they do in the Sacramento Valley; and that Cl plays a significant role at Fort Bragg.

INTERSPECIES CORRELATIONS

Correlation analyses were performed on the chemical/elemental data described previously, and on meteorological and agricultural burning data. Presented in detail in Appendix D, these correlations permit a more cogent interpretation of the data produced by filter analysis. With very few exceptions, the correlations substantiate the soil, auto, and fuel oil groupings hypothesized in the subsection on theoretical concepts.

Three meteorological variables were used: average daily wind speed, number of days since ≥0.25 in. of rain (DR), and an index of atmospheric moisture (AM), created by subtracting the average daily dew point temperature from the average daily temperature. It should be noted that AM increases with increasing dryness of the air. Because these data were not readily available for each of the special study sites, local climatological data (LCD) from National Weather Service stations were assigned to sites in the following manner:

Study site	LCD station
Bakersfield (Flower)	Bakersfield
Visalia	Fresno
Parlier	Fresno
Fresno (Cal State)	Fresno
Five Points	Fresno
Merced	Stockton
Modesto (J St)	Stockton
Woodland	Sacramento
Live Oak	Sacramento
Chico	Red Bluff

Given their distances from NWS stations, Taft, Kern Refuge, Fort Bragg, and Paso Robles were subjected to correlation analyses without the inclusion of meteorological variables.

The effect of agricultural burning was also looked at for the three Sacramento Valley sites. Burn data, extracted from a computer tape record provided by ARB, were found to be as shown in Table 5-8. Because of the small number of days when rice was burned, the total amount of material burned (rather than the amount of rice alone) was used as a variable in subsequent correlation analyses.

To illustrate the types of correlations that were observed, correlations for Bakersfield (Flower) are presented in Table 5-9. Fourteen elements, SO_4^-, and TSP concentrations produced on 16 days of sampling were used to produce this matrix. Concentrations of Co, Zn, and BSO were below the minimum detectable level too frequently to be included. Further, average daily wind speed, the number of days since ≥0.25 in. of precipitation, the index of atmospheric moisture, and the amount of agricultural material burned per day were not included for this specific analysis although they were at all other sites.

At a 95 percent confidence level and using the same qualitative terminology applied to intersite correlations in Section 3, Table 5-9 reveals the following distribution of correlation coefficients: 8 excellent (all among soil group elements), 3 very good (all soil group elements), 18 good, 11 fair, 19 poor, and 60 very poor. Among the good correlations are most of the soil elements with TSP, Br/Pb and S/P. In the poor category are Ni/V (which suggests that some portion of each of these elements is emitted by sources other than crude oil combustion), S/SO_4^-, and V/SO_4^-. In the very poor category are S, V, Pb, and Br with the soil elements. In general, these data suggest that the raw data are empirically valid and generally confirm the hypothesized source groupings.

Two questions that arise are: (1) what element correlates most strongly with TSP, and (2) what element does the same for $SO_4^=$? Potassium, a soil group element, has the strongest relationships with TSP at ±0.82, whereas V and S have the strongest relationships with $SO_4^=$ at +0.52. The latter relatively low coefficient probably reflects the diversity of sources of S (i.e., autos and crude oil combustion) and the time-delayed conversion mechanisms associated with SO_4^-.

With regard to the other special study sites, Table 5-10 lists the strongest species/TSP correlations found at each of these sites. Parlier is clearly dominated by soil group elements, as are Fresno (Cal State), Five Points, and Woodland.

TABLE 5-8. AGRICULTURAL BURNING NEAR SPECIAL STUDY SITES

Date	Material burned by site, tons					
	Woodland[a]		Live Oak[b]		Chico[c]	
	All	Rice	All	Rice	All	Rice
1977 7/6	1,292	d	687	d	2,154	d
7/18	3,713	d	4,082	d	3,368	d
7/24			14	d	34	d
8/11	d	d	d	d	180	d
8/17			d		1,101	d
8/23	675	d	1,339	d		
9/4	d	d	5	d	27	d
9/16					117	d
9/22			2,400	d	2,344	d
9/28	123	d	434	d		
10/4					10,451	10,239
10/10	d	d	7,487	5,382	9,570	7,381
10/22	d	d	d	d		
10/28					20,410	16,770
11/3			11,144	9,543	1,920	d
11/9	4,154	3,138	95	d	95	d
11/27	d	d	d	d	d	d
12/9	724	d	5,026	3,750	4,598	3,278
12/27	11	d			681	d
12/30			75	d		
1978 1/8	d	d			173	d
1/26	d	d			91	d
2/1			533	d	1,491	500
2/7	2	d			d	d
2/13					45	d
3/3	27	d			d	d
3/15	42	d			680	d
3/21			242	d		
3/27	d	d	215	d		
5/2						
5/10						
5/14						
5/27					d	d
6/7						

[a] Data consist of the sum of Yolo and Solano County burnings.

[b] Data consist of the sum of Butte, Yuba, and Sutter County burnings.

[c] Data consist of the sum of Butte, Glenn, and Tehama County burnings.

[d] No burnings on that day.

TABLE 5-9. INTERSPECIES CORRELATIONS AT BAKERSFIELD (FLOWER)

	Correlation coefficient																							
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP	WS	DR	AM	AB
Al	1.00																							
Mg	.94	1.00																						
P	.58	.57	1.00																					
S	.21	.25	.83	1.00																				
K	.97	.90	.64	.29	1.00																			
Ti	.94	.80	.47	.16	.94	1.00																		
V	.26	.22	.58	.60	.30	.31	1.00																	
Cr	.77	.77	.62	.37	.68	.68	.46	1.00																
Mn	.85	.80	.53	.29	.85	.87	.48	.74	1.00															
Fe	.95	.83	.62	.28	.97	.97	.35	.67	.84	1.00														
Co																								
Ni	.76	.73	.69	.54	.79	.71	.50	.70	.83	.75		1.00												
Cu																								
Zn																								
Br	.08	.02	.08	.26	.19	.19	-.10	-.30	.03	.24		.02			1.00									
Pb	.29	.24	.45	.55	.41	.38	.29	.00	.20	.47		.23			.82	1.00								
Cl	-.42	-.45	-.51	-.27	-.41	-.38	-.36	-.55	-.55	-.41		-.53			.43	.11	1.00							
$SO_4^=$	-.09	-.09	.29	.52	-.04	-.01	.52	.12	.06	-.06		.27			.14	.23	-.06	1.00						
BSO																								
TSP	.75	.70	.79	.62	.82	.72	.48	.52	.75	.79		.78			.21	.50	-.48	.08		1.00				
WS																								
DR																								
AM																								
AB																								

[a] Based on 16 samples

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

TABLE 5-10. STRONGEST CORRELATIONS WITH TSP AT SPECIAL STUDY SITES

Bakersfield (Flower)

16 samples

K = +0.82
P = +0.79
Fe = +0.79
Ni = +0.78
Al = +0.75
Mn = +0.75

24 samples

Ni = +0.80
K = +0.77
Fe = +0.77
Mn = +0.75
Al = +0.74

Taft

Fe = +0.87
K = +0.84
Al = +0.81
Ni = +0.80
Mn = +0.80

Kern Refuge

S = +0.74
Ni = +0.73
Cu = +0.73
Pb = +0.63
Ti = +0.60

Visalia

Mg = +0.86
Fe = +0.82
Al = +0.81
K = +0.78
Ni = +0.74

Parlier

Mn = +0.85
K = +0.79
Mg = +0.76
Fe = +0.76
Al = +0.74

Fresno (Cal State)

K = +0.81
DR = +0.77
Al = +0.76
Mg = +0.75
Mn = +0.75
Fe = +0.75

Five Points

Fe = +0.87
Mn = +0.87
Mg = +0.85
K = +0.84
Al = +0.80

Merced

S = +0.86
Cr = +0.85
Mn = +0.69
Al = +0.68
P = +0.68
K = +0.68
Fe = +0.68

Modesto (J St)

S = +0.86
K = +0.86
Fe = +0.82
Pb = +0.81
Ti = +0.78

Woodland

Fe = +0.90
K = +0.88
Al = +0.86
Mn = +0.80
Ti = +0.76
Mg = +0.76

Live Oak

Fe = +0.87
Al = +0.81
Mg = +0.80
Ti = +0.72
K = +0.70

Chico

Fe = +0.80
Al = +0.76
S = +0.76
K = +0.76
Ti = +0.74

Fort Bragg

S = +0.77
K = +0.77
Mn = +0.57
Fe = +0.45
Al = +0.42

Paso Robles

S = +0.95
Fe = +0.93
$SO_4^=$ = +0.88
K = +0.86
NO_3^- = +0.77
BSO = +0.77

Taft and Visalia are also dominated by soil elements, differing only in that Ni shows a strong relationship with TSP. Merced differs insofar as S, Cr, and P show strong correlations, especially S at +0.86. The strength of S/TSP and Pb/TSP correlations differentiate Modesto (J St) from the other sites. Sulfur is the only nonsoil element to show a strong correlation at Chico and Fort Bragg. Kern Refuge is dominated by elements that are not normally associated with the soil group. Secondary particulates--perhaps suggesting that transport from Los Angeles is a common occurrence--dominate at Paso Robles.

Strong species/$SO_4^=$ correlations are given in Table 5-11. They are not easy to interpret. Parlier, Woodland, Live Oak, and Chico show no correlations stronger than 0.50, suggesting the possibility that $SO_4^=$ measured at these sites is a result of medium- to long-range transport. Sulfur has the strongest relationship with $SO_4^=$ at Bakersfield (Flower), Taft, Visalia, Fresno (Cal State), Five Points, Merced, and Paso Robles. Correlation data are not available for Kern Refuge and Fort Bragg due to the lack of $SO_4^=$ data.

Two final correlation data relate to the auto group elements and the TSP/dry soil conditions. Correlations for Pb/Br range from +0.47 to +0.91 at all of the sites except Kern Refuge, Parlier, and Paso Robles. These sites, which have correlations ranging from -0.08 to +0.21, are clearly not significantly impacted by autos as a source. Correlations for TSP/DR are quite variable as the following data suggest:

Site	Sample correlation, TSP/DR
Bakersfield (Flower)	+0.35
Visalia	+0.60
Parlier	+0.46
Fresno (Cal State)	+0.77
Five Points	+0.58
Merced	+0.21
Modesto (J St)	+0.09
Woodland	+0.50
Live Oak	+0.65
Chico	+0.48

Of these, only the Fresno (Cal State) and Live Oak correlations (>+0.25 at 95 percent confidence level) can be considered significant.

TABLE 5-11. STRONGEST CORRELATIONS WITH $SO_4^=$ AT SPECIAL STUDY SITES

Bakersfield (Flower)

16 samples

S = +0.52
V = +0.52
P = +0.29
Ni = +0.27
Pb = +0.23

24 samples

No data

Taft

S = +0.85
V = +0.79
P = +0.66
TSP = +0.48
Ni = +0.34

Kern Refuge

No $SO_4^=$ data

Visalia

S = +0.51
WS = -0.44
V = +0.33
Fe = +0.27
K = +0.25
Mn = +0.25

Parlier

TSP = +0.29
Pb = +0.21
Cr = -0.19
V = -0.12
Ni = -0.11

Fresno (Cal State)

S = +0.79
TSP = +0.57
Mn = +0.43
WS = -0.43
K = +0.40

Five Points

S = +0.58
AM = -0.42
V = -0.33
WS = -0.24
TSP = -0.23
Mn = +0.23

Merced

S = +0.61
TSP = +061
Cr = +0.57
Mn = +0.47
Ni = +0.47

Modesto (J St)

TSP = +0.68
K = +0.65
S = +0.63
Ni = +0.60
Ti = +0.59

Woodland

Cl = +0.50
Mn = +0.31
S = +0.30
DR = +0.27
AM = +0.23

Live Oak

DR = +0.65
Ni = +0.56
WS = +0.55
Fe = +0.46
AM = +0.46

Chico

Cu = +0.42
V = -0.42
Pb = -0.36
Br = -0.34
DR = +0.31

Fort Bragg

Insufficient $SO_4^=$ data

Paso Robles

S = +0.91
Fe = +0.88
TSP = +0.88
Mn = +0.84
K = +0.80

FACTOR ANALYSIS

Factor analysis is a general term that refers to a variety of statistical techniques, which permit a set of variables (such as the raw chemical/elemental data given in Appendix C) to be represented by a hypothetical set of common or underlying source variables. A brief description of the technique is presented in the document entitled Digest of Ambient Particulate Analysis and Assessment Methods.[8] More refined discussions are presented in Introduction to Factor Analysis and Factor Analysis.[9,10] For the purposes of this report, the technique will be described only to the extent to which communication would otherwise be impossible and to which readers, versed in the technique, will know what specific variant of factor analysis was applied.

The factor analysis program contained in Version 7 of the Statistical Package for the Social Sciences (SPSS) was used. There are four basic steps to SPSS factor analysis as applied herein: data collection and preparation of a correlation matrix; extraction of initial factors; rotation to a terminal solution; and interpretation of the resulting factors. The raw data given in Appendix C were statistically analyzed to produce the correlation matrices given in Appendix D. These matrices were then used in the factor analysis program. The version of SPSS used was the common factor model (with iterations, or PA2). Application of VARIMAX rotation was then made to obtain terminal solutions. A summary of the key terms related to factor analysis and used herein is given in Table 5-12.

A correlation matrix based on 16 days of sampling at Bakersfield (Flower) was presented previously in Table 5-9. These data produced the rotated factor matrix shown in Table 5-13. Factor loadings of 0.6 or greater (regardless of the sign) were defined as being strong, 0.4 to 0.59 as being moderate, and less than 0.4 as being weak.

Three factors (i.e., sources of variation in the data set) were identified for the 16 sample data set: a soil group (windblown plus fugitive dust), a fuel oil factor (probably crude oil combustion), and an auto exhaust factor. The soil group consisted of strong loadings of Al, Mg, K, Ti, Cr, Mn, Fe, Ni, and TSP and moderate loadings of P and Cl. The Cr and Ni loadings were not expected but, as reported below, were consistently found to be part of the soil group at all sites investigated. With some exceptions, this was taken to mean that there were no other significant sources of these elements near the special study sites. The moderate loading of P implied that agricultural fertilizer was a contributor to measured TSP levels. The moderate negative loading for Cl was interpreted to reflect the influx of maritime air and its inverse relationships with dry, dusty soil conditions. This interpretation was based primarily on the

TABLE 5-12. SUMMARY OF KEY FACTOR ANALYSIS TERMS

Term	Description
Factor analysis	A variety of statistical techniques whose common objective is to represent a set of variables in terms of a smaller number of hypothetical source variables (i.e., factors)
Communality	The proportion of variance of an observed variable (e.g., Al) explained by the common factors (equal to the sum of factor loadings for the variable)
Common factors	Factors (i.e., hypothetical source variables) that are involved in the creation of more than one observed variable
Factor loading	Correlation between a factor and a variable
Eigenvalue	A mathematical construct which measures the relative importance of a discriminate function (equal to the total amount of variance accounted for by a factor; also equal to the sum of the squared factor loadings)
VARIMAX	A method of simplifying the columns of a factor matrix, hence maximizing the variance of the squared loadings in each column; it generally achieves a simpler and theoretically more meaningful factor pattern
Variance	The degree of dispersion (or variability) of a variable $\mathrm{Var} = \Sigma\ x_i - \bar{x}^2\ /n$
Covariance	A statistical measure of the extent to which values of one variable (e.g., TSP) tend to covary with values of another variable (e.g., Pb) $\mathrm{COV}(x,y) = \Sigma\ (x_i - \bar{x})(y_i - \bar{y})\ /n$

TABLE 5-13. BAKERSFIELD (FLOWER) ROTATED FACTOR MATRIX[a]

Variable	Soil factor	Fuel oil factor	Auto factor	Communality, h^2
Al	1.00	.03	.04	1.00
Mg	.91	.08	-.03	.83
P	.54	.71	.05	.80
S	.16	.93	.22	.94
K	.98	.11	.16	.99
Ti	.94	.03	.14	.90
V	.26	.70	-.09	.56
Cr	.73	.32	-.35	.76
Mn	.88	.22	-.08	.83
Fe	.96	.11	.20	.97
Ni	.75	.46	-.08	.79
Br	.05	.03	.99	.98
Pb	.25	.37	.82	.87
Cl	-.47	-.32	.43	.51
$SO_4^=$	-.11	.60	.07	.37
TSP	.74	.45	.18	.79
Total variation, %	55.3	15.6	13.1	83.9
Common variation, %	67.5	18.0	14.5	
Eigenvalue	8.69	2.31	1.87	

[a] Based on 16 samples.

relationships between days since rain, wind speed, and Cl as tabulated in Appendices D and E.

The second identifiable factor has strong loadings of P, S, V, and SO_4^- and moderate loadings of Ni and TSP. Although the presence of P initially complicated the interpretation, this factor was clearly coincident with crude oil combustion. Subsequent investigation by the ARB revealed that P is found either as a particulate or dissolved in the underground water of Kern County, that the P-contaminated water is injected in the crude oil burners, and that it is released in the particulate exhaust.[11]

The third factor was automotive exhaust. Strong loadings are found for Pb and Br and moderate loadings for Cl. Perhaps the only surprise was that S was not a part of this group; however, when the amounts of S emitted by crude oil processes were taken into account, the surprise disappears. In fact, this is a very important point concerning the interpretation of factor analysis results. An expected strong loading of a specific element on a specific factor can disappear if there are other sources of that element near the site.

Can these data be interpreted in terms of the relationships between each of these three factors and TSP? Yes, for if Table 5-12 is reviewed, it will immediately be recognized that a variable's loading on a given factor is in fact the correlation between that variable and the factor. Likewise, it can be said that the square of a variable's factor loading equals the percent of total variance (square of the standard deviation) in that variable accounted for by that factor. Thus, in Table 5-13, TSP has loadings of 0.74, 0.45, and 0.18 on the soil, fuel oil, and auto factors, respectively. Therefore, the soil factor accounts for 54.8 percent of the variance in TSP. Likewise, the fuel oil and auto factors account for 20.3 and 3.2 percent. The remaining 21 percent of TSP is unexplained by the three common factors.

It is instructive to compare these factor analysis results with those obtained by the contractor in analyzing Bakersfield elemental data produced by Dr. Cahill in December 1976. Based on 31 days of sampling for 16 variables (Na, Al, Si, S, Cl, K, Ca, Ti, V, Mn, Fe, Ni, Zn, Br, Pb, and TSP), four factors were obtained: soil, which explained 57.8 percent of the variance in TSP; auto exhaust, which explained 24.9 percent; fuel oil, which explained 14.1 percent; and an unknown Na (negative) and S factor, which explained 1.4 percent. In general, these results are quite similar to those produced with the contractor's data.

It is extremely important to note what is being explained and what is not. The percents given are not percents of TSP. Rather, they are percents of the degree of dispersion (or variability) in a variable.

Factor analysis was applied to the other special study sites in exactly the same manner as that described; the results, in terms of percent of TSP explained by identifiable factors, are given in Table 5-14.

The 24 sample results for the Bakersfield (Flower) site are quite similar to those described for the 16 sample set described. Now the Ni assumes a moderate loading due to the fact that four of the eight added days of sampling are winter days. This change is also reflected in the emergence of Ni as a strongly loaded variable in the fuel oil factor. Atmospheric moisture (in terms of increasingly dry air) also is strongly loaded in the soil factor. The auto factor changes slightly, in that its share of the variance in S increases to the point where that variable assumes a moderate loading. Wind speed has a strong negative loading and atmospheric moisture has a moderate negative loading. The fuel oil factor does not change significantly except for Ni; however, two new factors emerge. Days since significant precipitation, a new variable, emerges as its own factor. Likewise, maritime air becomes a separate factor with a strong loading of Cl. As shown in Table 5-14, the percents of variance in TSP explained by the various factors are similar to that for the 16 sample set, differing primarily in the increased effect attributable to the auto factor.

The three factors found in Bakersfield were also found in Taft. The soil factor explained ~69 percent of the variance in TSP, followed by fuel oil combustion (~25 percent). Although identifiable as a factor, automobile exhaust fails to explain any of the variance in TSP.

Kern Refuge, the most isolated site of those investigated in the San Joaquin Valley and located midway between Taft and Bakersfield, shows a rather surprising factor matrix. The soil group consisting of the standard group of elements (with the exception of Cr and Mn) explains only 0.5 percent of the TSP variance. An unidentified Cr/Mn/Zn factor explains 4 percent, but ~65 percent is explained by the fuel oil factor. If correct, these data suggest that detailed study of the Kern Refuge site would be a fertile area for future investigation.

The soil factor is clearly the dominant influence on variance in TSP at Visalia. By itself, that factor explains ~67 percent of the TSP variance. Of the other identifiable factors, the largest of which has been somewhat hesitantly designated as a fuel oil factor, none explains more than 7 percent of the variance.

Variance in TSP concentrations at Parlier is, according to Table 5-14, attributable primarily to the soil factor and secondarily to $SO_4^=$ transport and a S/Br source difficult to interpret.

TABLE 5-14. PERCENT OF VARIANCE IN TSP EXPLAINED BY COMMON FACTORS AT SPECIAL STUDY SITES

Site	Factor, % variance							
	Soil	Auto	Fuel oil	Maritime air	Secondary $SO_4^=$	Fertilizer	Other	Unexplained
Bakersfield (Flower)								
16 samples	54.8	3.2	20.3		a			21.7
24 samples	42.3	12.3	24.0	2.6	a		1.2[b]	17.6
Taft	68.9	0.0	25.0		a			6.0
Kern Refuge	0.5		65.6		a		4.0[c]	29.0
Visalia	67.2	2.0	6.8		0.5		1.7[d]	22.0
Parlier	54.8	2.0		e	13.7		13.0[f]	17.0
Fresno (Cal State)	38.4	14.4		1.4	29.2			16.0
Five Points	68.9			1.4	1.0		5.3[g]	23.0
Merced	14.4	64.0	4.4				2.0[h]	14.0
Modesto (J St)	37.2	46.2	0.0	4.8			2.9[i]	9.0
Woodland	54.8	32.5	3.2		0.0	a	2.6[j]	6.0
Live Oak	74.0				0.4	0.2	4.8[k]	21.0
Chico	49.0	24.0	0.1			0.2	7.8[b]	19.0
Fort Bragg	6.8			65.6[l]		0.6		27.0
Paso Robles	92.2	0.4			m		3.5[n]	4.0

[a] Included in fuel oil factor.
[b] Dryness factor.
[c] Unidentified Cr/Mn/Zn factor.
[d] Unidentified Cr/Ti factor.
[e] Included in auto factor.
[f] Unidentified S/Br/Ti factor (11.6), dry soil factor (1.4).
[g] Unidentified Ti/Cr/Al/Mg/Fe/DR factor.
[h] Wind speed factor.
[i] Unidentified Al factor.
[j] Agricultural burning factor.
[k] Unidentified V/Cr/Ti/Mn factor (4.0), agricultural burning factor (0.8).
[l] Includes wood boiler factor.
[m] Included in soil factor.
[n] Unidentified Cr/Ni/Ti/K factor (3.2), aged aerosol factor (0.2), unidentified Mg/P/Cl factor (0.0).

Strong soil loadings are found for Al, Mg, K, Ti, V, Cr, Mn, Fe, TSP, and atmospheric moisture. Moderate loadings are found for Cl (negative) and days since rain. The only surprise is V and that is attributable to the lack of any fuel oil sources within ~20 miles of Parlier. A second factor is strongly loaded on Br and S and is moderately loaded on Ni. This appears to be a source that involves the combustion of a sulfur-containing material, but it may be a statistical artifact of low Br concentrations. A third factor is strongly loaded on wind speed and moderately loaded on Pb (negative) and Cl. This is best interpreted as a combined auto/maritime air factor. Days since rain is strongly loaded on a fourth factor and is accompanied by moderate loadings of Al, Mg, K, and Ni. This can only be described as a second soil factor. Lastly, there is a strong loading for $SO_4^=$ on a fifth factor. This is interpreted as reflecting $SO_4^=$ transport.

Fresno (Cal State) TSP variance is attributable to three major factors: soil (~38 percent), secondary $SO_4^=$ (~29 percent), auto exhaust (~14 percent). The factor matrix shows that the soil group is comprised of the expected variables and is surprising only insofar as the days since rain and atmospheric moisture loadings are so strong and insofar as V, which was expected to create its own factor, was a part of the soil factor. A second factor was strongly loaded on S and $SO_4^=$ and moderately loaded on TSP and wind speed (negative). This appears to reflect locally generated sulfate inversions. Strong loadings of Pb and Br and moderate loadings of wind speed and atmospheric moisture comprise the third factor. Maritime air, the fourth factor, receives strong Cl loadings.

The factor matrix for Five Points is much as would be expected for a rural site. Approximately 69 percent of the variance in TSP is explained by the soil factor. Another ~5 percent is explained by a second soil-related factor that is dominated by Cr and Ti. This is intriguing in that a similar Cr/Ti source was found at Visalia. Two other factors, secondary $SO_4^=$ and maritime air, together explain only ~2 percent of the TSP variance.

Merced, according to Table 5-14, has ~64 percent of its TSP variation attributable to auto exhaust. This apparently incongruous result is completely consistent with the microinventory of the site (see Appendix F), which shows that the heavily traveled California Highway 99 is elevated above and ~500 feet due east of the sampler. This auto factor is strongly loaded on S, Cr, Br, Pb, and TSP and is moderately loaded on P, Mn, Fe, Ni, $SO_4^=$, and wind speed (negative). These loadings clearly suggest a significant reentrained dust effect. The soil factor, which contributes only ~14 percent of the variance in TSP, is strongly loaded on all the standard soil group elements, P, days since rain, and atmospheric moisture. The loading for P may be a function of agricultural fertilizer. The third factor, fuel oil, explains 24 percent of the TSP variance and is strongly loaded only on V. Moderate loadings for that factor are associated with SO_4^- and wind speed (negative). There is also a very minor fourth factor that received a moderate wind speed loading.

The Modesto (J St) data indicate that there are two major sources of TSP at that site: soil, with ~37 percent of the variance, and auto exhaust, with ~46 percent of the variance. With the exception of Al, the soil group again creates the soil factor; S and V also receive moderate loadings for that factor. Phosphorous, S, Br, Pb, and TSP are strongly loaded and K, Ni, and SO_4^- moderately loaded on the auto factor. The strong loading for P is inexplicable, unless P is used as a gasoline additive in California or if it is used as a fertilizer on nearby agricultural fields and has been deposited on nearby roads for subsequent reentrainment. The third factor is strongly loaded on days since rain and atmospheric moisture and moderately loaded on V, indicating simply that fuel oil is burned mainly in the winter months. A maritime air factor is loaded strongly on Cl (negative), SO_4^-, and wind speed (negative). Lastly, there is an unknown factor that is loaded strongly only on Al. This most likely reflects an industrial source.

As at most sites, the soil factor plays a significant role at Woodland. It explains ~55 percent of the variance in TSP concentrations. A fertilizer/fuel oil factor, which has heavy loadings on P and V (negative) and a moderate loading on DR, explains ~3 percent. The surprising linkage between V and P may be the result of different patterns of these elements' emissions. Emitted by fuel oil, V tends to peak in the winter months whereas P, most likely associated with fertilizer, tends to peak in the summer. A secondary SO_4^- factor, consisting of a heavy SO_4^- loading and a moderate Cl loading, explains very little variance in TSP. The agricultural burning factor, consisting only of a heavy loading on that variable, explains ~3 percent. Lastly, an automotive exhaust factor, which has heavy loadings on S and wind speed (negative) and moderate loadings on Pb and TSP, explains ~32 percent of the variance.

Five factors were found at Live Oak, easily the most significant of which was the soil group. It alone accounts for ~74 percent of the variance in TSP. Interpretation is somewhat complicated, however, by the fact that a second soil group was also found. A second factor, which has strong loadings on Ti, V, Cr, and Mn as well as moderate loadings on Mg, K, Pb (negative), and atmospheric moisture, appears to be a soil-related source (perhaps a nearby agricultural field or unpaved road) that has a slightly different elemental composition than surrounding soils. A third factor is strongly loaded on SO_4^- and wind speed and moderately loaded on days since rain. The relationship with wind speed is the opposite of what was found at other sites and clearly implies that the $SO_4^=$ is not the result of local inversions. The fourth factor has a strong P loading and probably reflects fertilizer usage. Lastly, a moderate loading on agricultural burning creates a fifth factor. It should be noted that none of the elements have more than a weak loading on this factor.

The soil factor is quite significant in Chico (~49 percent of the TSP variance) and is comprised of the standard elements and moderate loadings on S, days since rain, and atmospheric moisture. The S loading probably reflects the presence of gypsum in the soil. The auto factor receives moderate loadings on S, TSP, and wind speed (negative) in addition to strong Pb and Br loadings. The fuel oil factor is mainly V. Days since rain and SO_4^- (both moderately loaded) create a dry soil factor. Lastly, there is a fertilizer factor that consists of a strong P loading and a moderate negative loading on agricultural burning.

Three factors were found at Fort Bragg, one of which is the expected soil factor. That factor, which explains only ∿7 percent of the variance in TSP, is accompanied by a P-factor which explains ∿1 percent of the variance. Easily the most significant factor is one which is heavily loaded on K and Ti and moderately loaded on Mn and Cl. A facile interpretation of these data would be that this factor represents the effect of sea salt, but reference to the emission data presented in Table 5-15 complicates the issue. Of the 17 elements initially measured, K and Cl are the major trace elements emitted by wood burning boilers, but these elements are also emitted in significant quantities by sea salt. The only conclusion is that this factor represents the combined effect of maritime air and the wood burning boilers in Fort Bragg.

Five factors were found in Paso Robles. The first, soil, explained virtually all of the TSP variance (∿92 percent) and is characterized by the somewhat surprising inclusion of $SO_4^=$, NO_3^-, and BSO. The next most significant factor, an unidentified Cr/Ni/Ti/K factor, explained only ∿3 percent of the variance. The remaining factors explained less than 1 percent of the variance.

CHEMICAL ELEMENT BALANCE

The study design called for the construction of chemical element balances (CEB) for each of the special study sites. By this method, the elemental data reported in this subsection could be used to estimate mass contributions from each of the identifiable source categories. As in the case of factor analysis, the description of the CEB method provided herein will be brief. Further detail can be found in the published literature.[8,12]

TABLE 5-15. CONCENTRATION OF TRACE ELEMENTS IN WOOD BURNING BOILERS AND MARINE AIR, NORMALIZED TO K

(percent)

Element	Wood furnace[a]	Marine air[b]	Observed atmospheric ratio
Al	0.56		2.00
Fe	0.24		1.50
K	1.00	1.00	1.00
Ti	<0.04		0.07
Mn	0.07		0.25
V	<0.004		0.10
Cl	1.75	47.62	8.86
Cr	0.03		0.06
Ni	<0.02		0.06
Zn	<0.03		0.00
Cu	0.09		0.22
Co	<0.0004		0.00
Br	0.17	0.17	0.04
S		2.19	2.36
Mg		3.19	1.40

[a] Source: Shum, Y. Atmospheric Trace Elements and Their Application in Tracing Air Pollution.

[b] Rahn, K. A. The Chemical Composition of the Atmospheric Aerosol. University of Rhode Island, Kingston, Rhode Island. July 1976. [Wedepohl (1971) presented in Rahn.]

According to the CEB method, the atmospheric concentration of the ith element, C_i, is given by:

$$C_i = \Sigma_j m_j x_{ij}$$

where m_j = mass contribution to TSP of particles from source j, fraction

x_{ij} = concentration of element i in the particulate matter emitted by the jth source

There was no assurance that this method would produce satisfactory results. Rather than apply it indiscriminately to all 14 special study sites, the contractor decided to apply it to two test cases: Bakersfield (Flower) and Chico. In both cases, the daily atmospheric concentrations summarized in Table 5-5 and reported in Appendix C were used. Emission rates were those given in Table 5-1. A computer program graciously provided by G. S. Kowalczyk, was used, albeit in a slightly modified form.

More specifically, 4 sources (soil, marine, auto, and fuel oil), 13 elements (Al, Cl, V, Pb, Mg, S, K, Ti, Cr, Mn, Fe, Ni, and Br), 24 sets of atmospheric elemental concentrations, and the elemental emission rates (given in Table 5-1) were used for Bakersfield (Flower). The results, summarized in Table 5-16, were not encouraging. Although the relative magnitudes of the various source contributions were plausible, the overall amount of particulate matter accounted for (including secondary particulates) was <50 percent of that actually measured. This suggests a number of possibilities:

- The emission rates, especially for soil, were inappropriate
- The relatively small number of atmospheric samples statistically skewed the results
- There are other major sources that were not accounted for in the balance

Similarly, the results for Chico were not encouraging. Fertilizer and agricultural burning were initially added as sources, but the latter was quickly deleted after review of the initial program outputs. The similarity in elemental emission rates between that source and soil caused wildly erroneous predictions. After deleting agricultural burning, the results were much better (see Table 5-16) but still not good enough. A major factor causing erroneous results may well have been the lack of information on the P content of automotive exhaust.

TABLE 5-16. CONTRIBUTION OF SOURCES TO TSP CONCENTRATIONS

Source	Bakersfield predicted TSP, μg/m^3	Chico predicted TSP, μg/m^3
Soil	25.4	20.6
Marine air	0.3	0.0
Auto exhaust	3.8	4.6
Fuel oil	2.7	4.8
Fertilizer		4.5
Total primary particulates	32.2	34.5
Secondary particulates	37.1	7.8
Total TSP accounted for	69.3	42.3
Total TSP measured	147.4	78.0
Deviation	-78.1	-35.7

CONCLUSIONS

Chemical/elemental data have been presented for 14 special study sites. These data clearly indicate that, in most cases, windblown and fugitive dust are the major contributors to variations in TSP concentrations at these sites. Auto exhaust/reentrained dust is generally the second most significant source and is especially significant at Merced, Modesto (J St), and Chico. Fuel oil combustion, almost certainly crude oil, is significant throughout the extreme southern part of the San Joaquin Valley. Secondary $SO_4^{=}$ have a significant effect in Fresno and the southern half of the San Joaquin Valley. Lastly, Fort Bragg is exposed to major impacts from the combined effect of sea salt and wood burning boilers. These data do not permit a direct computation of source contributions.

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SECTION 6

APPLICATION OF MICROINVENTORY/EMPIRICAL PARTICULATE MODEL AT SELECTED SITES

INTRODUCTION

EPA has developed an empirical model which relates ambient air quality to TSP emissions in the area surrounding a hi vol sampler. The model evolved from a multiple linear regression analysis of data obtained from a technique referred to as a microinventory.

Microinventory data for 79 sites in four different cities were gathered during the developmental stage of the model. The contractor collected most of the data needed and provided it to EPA in a series of reports. Separate publications were prepared for the sites inventoried in each city: 32 sites in Kansas City,[1] 10 sites in Portland,[2] 11 sites in St. Louis,[3] and 14 sites in Birmingham.[4] Another contractor, Rockwell International, provided corresponding data for 12 sites in the RAMS sampling network in St. Louis. These data were also included in the St. Louis publication.[3]

Two subsequent reports presented data necessary to validate and evaluate the empirical model.[5,6] Microinventory data were collected for an additional 32 sampling sites in three areas: Philadelphia, Pittsburgh, and New England. Lastly, the model has been applied to mixes of urban and rural sites in Iowa, Nebraska, and Montana.[7,8,9]

The following subsections discuss the procedures used to microinventory sampling sites; the nature, derivation, and limitations of the empirical model; and the results of applying the model to 22 sites in California.

MICROINVENTORY PROCEDURES

Field Inventory

The survey procedure employed for the microinventories, conducted in November 1978 and February 1979, was to ground survey, via automobile, the sampler sites and all probable sources of emissions within a 1-mile radius of each. This method enabled the survey team to make the best observation of overall site exposure and to identify the sources with primary impact on the samplers. The 1-mile radius around each sampler was specified because that is approximately the range to which theoretical treatments (dispersion modeling) show that low level sources will have a significant impact.

Sources of fugitive dust and conventional point and area sources were located on maps during the ground survey and labeled with pertinent data, such as size and boundaries, observed activity and operational characteristics, and estimated emission rates. Two observers independently estimated and agreed upon parameters observed at each site to increase accuracy and completeness.

Special attention was given to sources located within 200 feet of the monitor. The distances to these sources were measured to ±5 percent and recorded. Distances to sources beyond 200 feet were scaled off U.S. Geological Survey maps.

Collection of Point Source Data

During the ground survey, an attempt was made to locate every significant point source. Annual TSP emissions for these and other sources were extracted from a point source listing provided by the ARB.

A table of point sources within 5 miles of the monitor was compiled for each of the sampler sites. Only those sources with estimated annual TSP emissions of 25 tons/yr or more were considered to be point sources. For the area between 1 and 5 miles from the sampler, the point sources were located using UTM coordinates and street addresses. Smaller sources listed in the point source file were included in the inventory only if they were located within 1 mile of a sampler. The emissions from these smaller sources were combined in an industrial process category and included as area sources.

Calculation of Area Source Emissions

The 1 mile radius areas were divided into nine sectors as shown in Figure 6-1. Based on data obtained from the survey, estimates were made of fugitive dust emissions in each sector. All identified fugitive dust sources within the survey area were recorded on the data sheet with estimates of size, location, and activity. The emission factors given in Table 6-1 were then applied to each source to calculate estimated annual emissions. (Derivations of emission factors are discussed in Appendix G.)

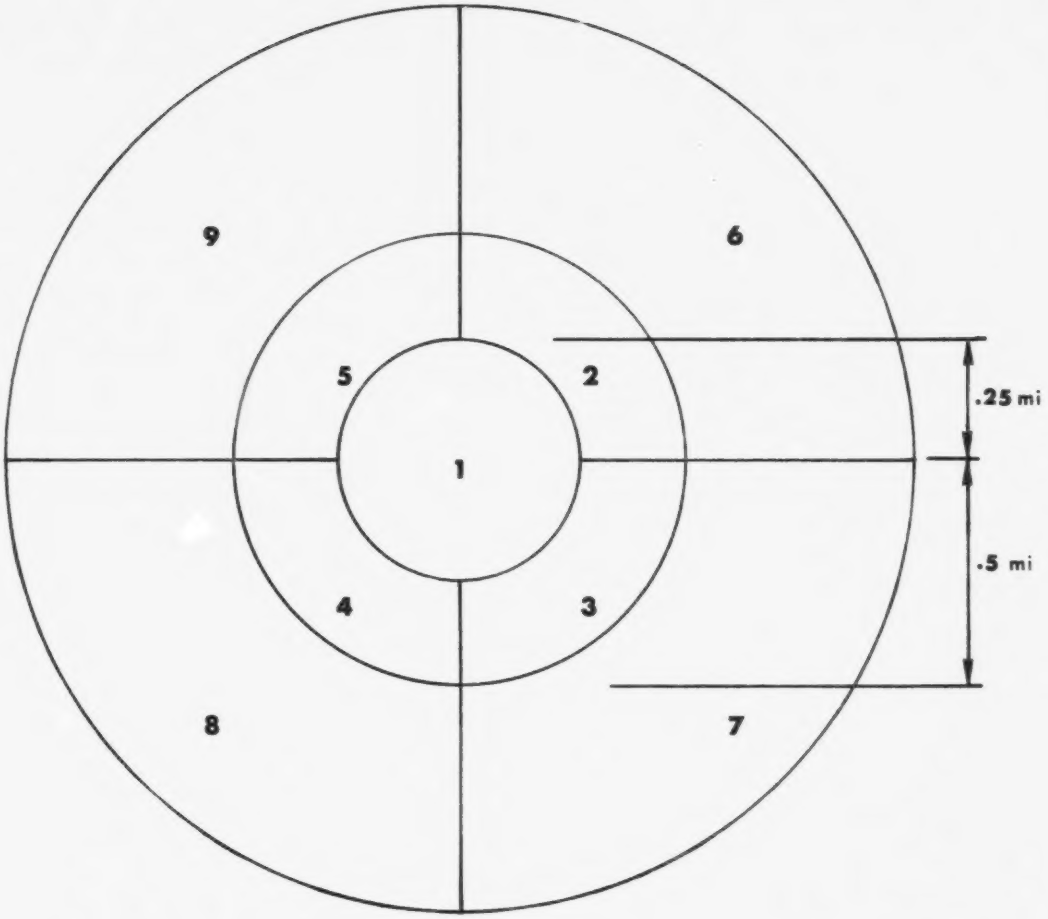
9
6
5
2
.25 mi
1
.5 mi
4
3
8
7

Figure 6-1. Area source sectors used for the survey areas.

TABLE 6-1. EMISSION FACTORS FOR MICROINVENTORY SITES

	Agriculture, ton/ac/yr				Reentrained dust, g/VMT		Exhaust/ tire wear, g/VMT		Unpaved roads, lots,& alleys, lb/VMT								
Site	orchards	vineyards	cotton	bare	clean	commercial	clean	commercial	10 mph	20 mph	30 mph	40 mph	Storage areas, ton/ac/yr	Railroad yards, ton/ac/yr	Aggregate storage, ton/ac/yr	Exposed areas, ton/ac/yr	Construction, ton/ac/mo
Bakersfield	a	a	a	a	4.5	19.2	.49	.98	1.8	3.5	5.3	7.0	a	.93	14.3	a	1.8
Flower					b	b	b	b	b	b	b	b	2.90	b	b	2.23	b
Chester					b	b	b	b	b	b	b	b	3.17	b	b	2.44	b
Taft					4.5	19.2	.49	.98	1.8	3.5	5.3	7.0	.95	.53	14.3	.73	1.8
Kern Refuge					4.5	19.0	.49	.98	1.7	3.5	5.2	6.9			14.3		1.8
Kettleman City					4.5	19.0	.49	.98	1.7	3.5	5.2	6.9			14.3		1.8
Visalia				.22	4.4	18.8	.49	.98	1.7	3.4	5.1	6.9	.22	.13	14.3	.17	1.8
Parlier	.05	.05		.20	4.4	18.8	.49	.98	1.7	3.4	5.1	6.9	.20	.11	14.3	.15	1.8
Fresno	a	a	a	a	4.4	18.8	.49	.98	1.7	3.4	5.1	6.9	a	.13	14.3	a	1.8
Olive					b	b	b	b	b	b	b	b	.22	b	b	.23	b
Cal State	.04	.04	.10	.20	b	b	b	b	b	b	b	b	.26	b	b	.17	b
Five Points	.07	.07	.19		4.4	18.8	.49	.98	1.7	3.4	5.1	6.9	.42	.53	14.3	.32	1.8
Coalinga				.58	4.4	18.8	.49	.98	1.7	3.4	5.1	6.9	.73	.60	14.3	.56	1.8
Merced				.17	4.3	18.5	.49	.98	1.7	3.4	5.1	6.8	.10	.13	5.9	.28	[illegible]
Modesto, J St					4.3	18.5	.49	.98	1.7	3.3	5.0	6.7	.29	.19	5.9	.22	[illegible]
Stockton					4.3	18.5	.49	.98	1.7	3.3	5.0	6.7	.23	.13	5.9	.18	[illegible]
Sacramento, P St	.02	.02	.06	.11	4.2	18.0	.49	.98	1.6	3.3	4.9	6.6	.10	.07	5.9	.08	[illegible]
Woodland				.10	4.2	18.0	.49	.99	1.6	3.3	4.0	6.6	.08	.09	5.9	.06	[illegible]
Sutter City	.01			.05	4.1	17.6	.49	.98	1.6	3.2	4.8	6.4	.06	.04	3.1	.05	[illegible]
Live Oak	.01			.03	4.1	17.6	.49	.98	1.6	3.2	4.8	6.4	.01	.01	3.1	.01	[illegible]
Chico	.01				4.1	17.3	.49	.98	1.6	3.2	4.7	6.3	.03	.03	3.1	.02	[illegible]
Red Bluff	.01			.04	4.1	17.3	.49	.98	1.6	3.2	4.7	6.3	.04	.04	3.1	.03	[illegible]
Fort Bragg					3.4	14.5	.49	.98	1.3	2.6	4.0	5.3	.03	.01	2.5	.02	[illegible]
Paso Robles					4.4	18.7	.49	.98	1.7	3.4	5.1	6.8	.16	.13	12.4	.12	1.5

[a] Values depend on soil type, so are site specific.
[b] Values are not site specific.

Conventional area source emissions not accounted for in the survey were included in order to determine total area source TSP emissions by sector. The categories of conventional area sources considered included emissions from fuel combustion, incinerators, locomotives, and small point sources. Emissions from these sources were usually obtained from a gridded inventory of area source emissions. The microinventory areas were superimposed on a map of the gridded inventory area; emissions were then apportioned to the microinventory areas from the grids on the basis of land area. These area source emissions were reapportioned to the nine sectors of the 1-mile radius area on the basis of land area. It was not practical with the available data to determine exact emissions by sector. Although this appears to negate the effect of sectoring, the conventional area source emissions are generally much less than those from fugitive dust or vehicle-related sources.

Emissions for two other sources, vehicle exhaust and reentrained dust from streets, were calculated for each sector based on the vehicle miles traveled (VMT) in each sector. These VMT data were calculated from information obtained through local public works and traffic engineering departments.

Only a brief description of the microinventory methodology is presented in this section. A more complete discussion of the technique can be found in the Digest of Ambient Particulate Analysis and Assessment Methods.[10]

DESCRIPTION OF THE EMPIRICAL PARTICULATE MODEL

The model was developed from a stepwise multiple linear regression analysis. The resulting equation has annual geometric mean TSP concentrations as the dependent variable and four independent variable terms. The independent variables are annual area source emissions within 1 mile, annual point source emissions within 5 miles, local sources (particularly traffic-related), and presence of dirt on the nearest street. These variables were arrived at by screening approximately 30 potential variables by simple linear regression and selecting the independent ones with the highest partial correlations. Stepwise multiple regression was then employed to derive the coefficients for each of the terms in the equation and to obtain the statistical values used to judge the accuracy of the regression equation.

As stated above, the data base for developing the model was generated at 79 sites in four cities. Each had measured concentrations, microinventory results, and other information such as surrounding land use and distances to the sources. The multiple correlation coefficient (r) with the four variables was 0.876 using all 79 data sets; none were eliminated as outliers. Therefore, the four variables explained 0.767 of the variance (r^2) in measured concentrations.

The resulting general equation is:

$$AVGAQ = 0.00451(AREA) + 0.00096(POINT) + 50.5(LOCAL) + 18.6(VISPLUME) + K$$

where AVGAQ = predicted annual geometric mean, $\mu g/m^3$

$$AREA = \left(\frac{A_1}{0.0324}\right)\left(\frac{25}{HGT}\right) + \left(\frac{A_2 + A_3 + A_4 + A_5}{0.16}\right) + \left(\frac{A_6 + A_7 + A_8 + A_9}{0.6084}\right)$$

A_i = total area source emissions in sector i, tons/yr (sector locations are shown in Figure 6-1)

HGT = height of sampler, ft

$$POINT = \sum_{i=1}^{n} \frac{PSEM_i}{D_i^2} (WWF)$$

n = number of point sources within 5 mi

$PSEM_i$ = emissions from point source i, tons/yr

D_i = distance to point source i, mi (lower limit of D_i is 0.25)

WWF = wind weighting factor, computed as wind frequency (%) in quadrant where source is located divided by 25, dimensionless

$$LOCAL = \frac{\ln ADT_1}{\sqrt{HGT^2 + DIS_1^2}} + \frac{\ln ADT_2}{\sqrt{HGT^2 + DIS_2^2}}$$

ADT_i = average daily traffic on nearby road i, vehicles/day

DIS_i = distance to road i, ft (upper limit of DIS_i is 200)

VISPLUME = 0 if no visible plume results from passing traffic, 1 if there is a plume

K = a constant determined from the average difference of measured and predicted air quality; K is unique for a given area

Validation of the model with data obtained from Philadelphia, Pittsburgh, and New England and subsequent applications of the model to Iowa, Nebraska, and Montana sites have proven rather successful. Table 6-2 presents a summary of these experiences in applying the model.

An explanation of the constant, K, and its derivation is appropriate at this point. As an output of the multiple linear regression program, K represents the portion of the predicted concentration that is not explained by the AREA, POINT, LOCAL, and VISPLUME terms of the equation. It is determined by calculating the average difference between measured and predicted concentrations (average residual). This unexplained portion is thought to have several distinguishable components. The largest component of K is probably background, the portion of ambient concentrations that cannot be reduced by controlling emissions from local man-made sources. Background in turn has many components, including windblown dust from natural surfaces, biological debris, and long-range transport. Background for an urban area is usually measured at a nearby nonurban site that is substantially unaffected by emission sources.

Two other probable components of the constant value could be collectively described as "urban or regional excess," in that these components would not be accounted for in a measured nonurban background concentration. The first of these is locally-emitted sulfates, nitrates, and organics that form secondary aerosols in the atmosphere. Long-range transport would include additional secondary aerosols that would be included in the background value described above. The second component would be the collective impact of area and small point sources located near a sampler but outside the 1-mile radius of the microinventory area.

Because the impacts of the above sources vary considerably from city to city but to a much smaller degree for different sites within the same urban area, the constant should also vary depending on the city. The problems associated with applying this concept to the sites modeled in California are discussed in the subsection below on model limitations.

When corrected by the average residual, the concentrations predicted at any one site should not differ from the measured concentration by more than 13.6 $\mu g/m^3$ (the standard error of the general equation). A value greater than 13.6 suggests that the sources impacting upon the affected site cannot be identified by the model, the concentrations measured at the site are erroneus, the emission calculations and allocations for the area are incorrect, or the model is not appropriate for application at the site.

TABLE 6-2. COMPARISON OF EMPIRICAL MODEL RESULTS FROM SIX STUDIES

Area	No. of sites	Mean local contrib, μg/m^3	Slope	Intercept	r	K	Root mean error	Sites outside std error, %
Philadelphia	10	28.6	1.16	65	+0.95	58.0	5.4	0
Pittsburgh	7	23.1	1.21	53	+0.94	69.7	10.2	29
New England	11	30.5	0.81	40	+0.93	34.0	6.6	0
Nebraska	7	31.0	2.87	13	+0.80	71.1	12.1	43
Iowa	14	22.6	1.28	50	+0.84	56.6	12.4	7
Montana	3	39.7	insufficient data			27.6	2.4	0

LIMITATIONS OF THE MODEL

Although the model has performed well in the areas that have been investigated thus far, there are some limitations that should be enumerated. The model is obviously limited by the accuracy of the microinventory data used. The calculated emission data need to be as accurate and complete as possible. Good emission estimates and precise locations are necessary for all point sources. Area source emission factors should be adjusted so they are specific to the survey area. Temporary fugitive dust sources, such as construction, identified during the microinventory should be evaluated for temporal consistency with air quality data before being included in the model. Also, traffic data should be as detailed as possible for streets in the microinventory area.

The constant K in the model presents another potential limitation. For example, the constant determined for Pittsburgh was 69.7 $\mu g/m^3$. Based on measured air quality data, approximately 55 $\mu g/m^3$ can be attributed to background. The remaining 15 $\mu g/m^3$ are attributed to locally generated secondary aerosols and to emission sources not included in the model. For a control agency interested in determining the sources contributing to high measured concentrations, a large undefined contribution simply adds to the complexity.

One potential application of the model has not been evaluated. This entails applying the model to a specific year. Because air quality data were limited, only an average of several years was available for comparison with the model's predictions. Given a sufficiently detailed inventory of sources and other necessary data for a particular year, the model should be able to applicable for that year.

The model was developed and validated primarily for urban areas with a mix of point, area, and fugitive dust sources. Although the model has been applied to numerous small town and small city sites, no formal effort has yet been made to evaluate the model with respect to rural areas. Because only 11 of the 20 sites modeled in California can be defined as urban (i.e., >10,000 population), the predictive capability of the model is exposed to a serious test.

The VISPLUME term in the model contributes either zero contribution or 18.6 $\mu g/m^3$, depending upon whether the person conducting the microinventory decided that a visible plume was evident from any street within 200 feet of the sampler. Given the potential impact of this term on the model's predicted concentrations, it is necessary to apply this term quite carefully.

EMPIRICAL MODEL RESULTS

The model was applied to 22 sites in California, 20 of which are located in the San Joaquin and Sacramento Valleys:

San Joaquin

Bakersfield (Flower)*
Bakersfield (Chester)*
Taft
Kern Refuge
Kettleman City
Visalia*
Parlier
Fresno (Olive)*
Fresno (Cal State)*
Five Points
Coalinga
Merced*
Modesto (J St)*
Stockton*

Sacramento

Sacramento (P St)*
Woodland*
Sutter City
Live Oak
Chico*
Red Bluff

Other

Fort Bragg
Paso Robles

* urban site

A five page summary was compiled for each site inventoried (see Appendix F). The first page of each summary is a complete description of the individual site including the SAROAD code, the street address, the UTM coordinates, the location and height of the monitor, topography in the vicinity of the site, localized sources within 200 feet of the monitor, and air quality data for up to a 5-year period.

The sampling site location and surrounding 1-mile radius survey area are shown on a map on the second page. Two photographs illustrating the sampler, one (whenever possible) viewed in the direction where the greatest potential for localized pollution influence exists, are presented on the third page of the summary.

A listing of all the point sources located within a 5-mile radius of the sampler are included on the fourth page. The listing is limited to those sources emitting greater than 25 tons/yr. Any source emitting less than 25 tons/yr and within 1 mile of the sampler is included under the industrial process area source category or allocated to the appropriate area source combustion category.

The fifth page summarizes the area source emissions for a 1-mile radius about the sampler site.

Using the site data presented in the five page summaries and the empirical model equation presented previously, predicted geometric means were computed for each site. As Table 6-3 and Figure 6-2 indicate, it was not very productive to group all California sites together. The average residual (K) was 77.3 $\mu g/m^3$, the linear regression equation was $y = 1.6x + 68.2$ with $r = +0.61$, and only six sites are within the standard error of the model. The most plausible reason for this comparatively poor performance is that the sites are drawn from too diverse areas to have a common residual value. Data are from two inland valleys covering an area of 75,000 square miles, plus two other sites located quite near the Pacific Ocean.

In recognition of this fact, a number of different site groupings were created to see which provided the best overall fit with measured data. Taft was excluded from all groupings because of problems associated with the representativeness of the sampling site. Kettleman City was excluded owing to a lack of adequate sampling data. Fort Bragg and Paso Robles were also excluded because of the difference between conditions at those sites and the sites in the two valleys. Results derived from the various site groupings are given in Table 6-4. As that table indicates, the accuracy (measured in terms of root mean error) of the empirical model improves considerably when the San Joaquin Valley and Sacramento Valley sites are separated. Table 6-4 also indicates that varying the site combinations generally does not produce a significantly better predictive capability.

There is one significant exception to this statement; it is based upon an observed gradient in residuals between Stockton and Bakersfield. As Figure 6-3 indicates, the distance downvalley from Stockton relates to the calculated residuals in the following manner: $y = 0.19x + 65.6$, where $r = +0.75$. When this equation is used to generate site specific K's, the resulting data compare quite well with measured concentrations (see Table 6-4). The average root mean error becomes only 8.9 $\mu g/m^3$, and the percent of sites that are outside the standard error of the model drops to 17 percent. This is a considerable improvement over the other predictive combinations.

When this predictive mechanism is used, a number of facts become evident:

- The local contributions from the areas microinventoried in California are considerably smaller than those microinventoried elsewhere.

- The correlation for the Sacramento Valley sites is quite poor.

TABLE 6-3. COMPARISON OF MEASURED VERSUS MODEL-PREDICTED TSP CONCENTRATIONS

($\mu g/m^3$)

Site	Measured average annual geom mean	Predicted annual geom mean conc, w/o K	Residual (measured-predicted)	Total annual geom mean conc
Bakersfield (Flower)	130.1	19.4	110.7	126.8
Bakersfield (Chester)	137.8	29.6	108.2	137.2
Taft	101.4[a]	39.4[a]	62.0[a]	a
Kern Refuge	82.6	1.6	81.0	101.4[b]
Kettleman City	c	11.9	c	c
Visalia	128.5	19.5	109.0	115.5
Parlier	121.7	14.5	107.2	105.9[b]
Fresno (Olive)	122.7	28.2	94.5	116.6
Fresno (Cal State)	104.8	13.8	91.0	102.2
Five Points	86.8	10.5	76.3	99.7
Coalinga	84.7	1.9	82.8	93.3
Merced	78.9	14.6	64.3	92.4
Modesto (J St)	102.4	19.8	82.6	90.7
Stockton	75.2	12.2	63.0	77.8
Sacramento (P St)	64.2	17.4	46.8	76.1
Woodland	68.6	8.4	60.2	67.1
Sutter City	73.6	7.0	66.6	65.7
Live Oak	87.1	12.8	74.3	71.5[b]
Chico	74.2	24.8	49.4	83.5
Red Bluff	59.4	4.3	55.1	63.0
Fort Bragg	98.6	23.4	75.2	d
Paso Robles	69.0	21.9	47.1	d

[a] Site excluded because of sampling site deficiencies.
[b] Predicted concentration outside the standard error of the model.
[c] Insufficient data.
[d] Site excluded because it is not located in the central valley.

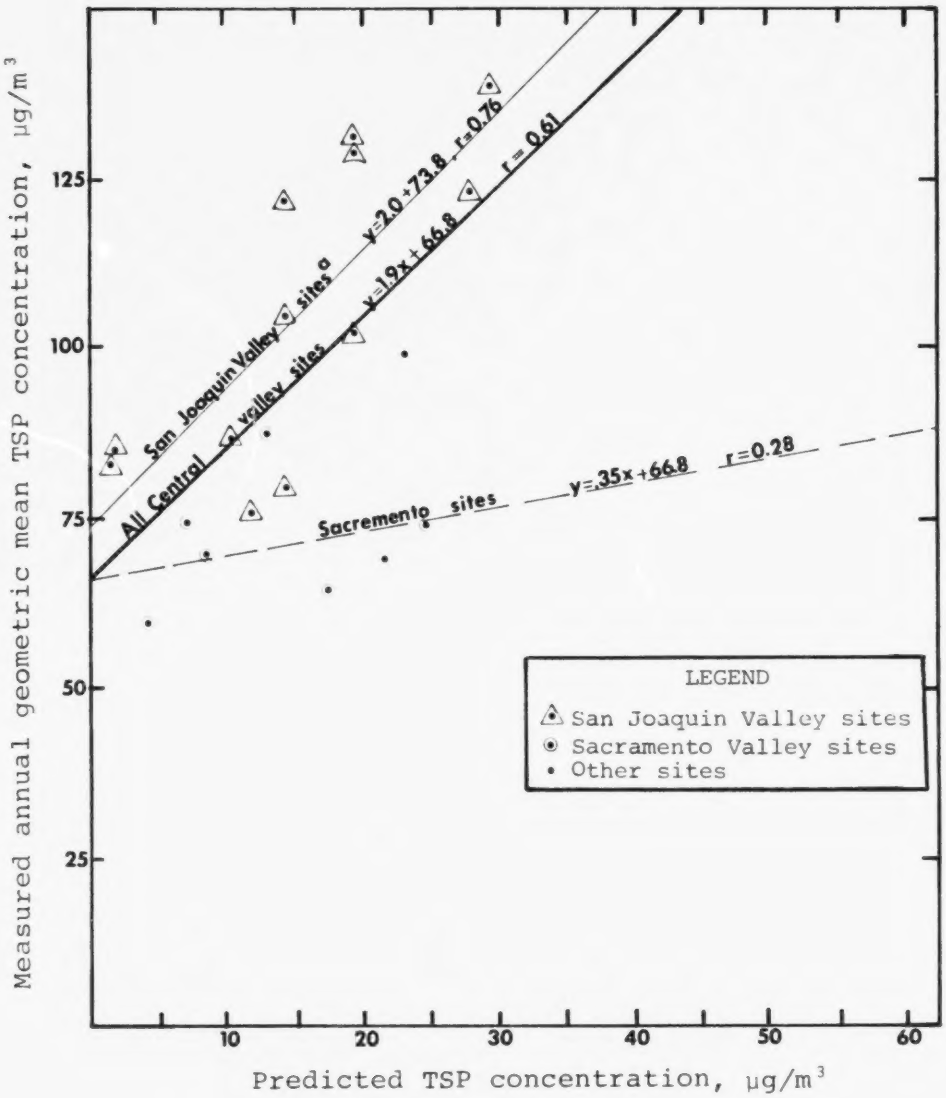

Figure 6-2. Measured versus predicted concentrations (without K) at selected sites.

TABLE 6-4. COMPARISON OF THE PREDICTIVE CAPABILITY OF VARIOUS SITE GROUPINGS

Area	No. of sites	Mean local contrib, $\mu g/m^3$	Slope	Intercept	r	K	Root mean error	Sites exceeding std error, %
All sites	20	15.3	1.60	68.2	+0.54	77.3	17.2	60
All central valley sites	18	14.5	1.87	66.8	+0.61	79.1	17.2	61
San Joaquin Valley	12	15.5	1.99	73.8	+0.76	89.2	12.2	39
Sacramento Valley	6	12.5	0.35	66.8	+0.28	58.7		
San Joaquin, minus Stockton	11	15.8	1.89	77.5	+0.79	91.6	12.4	44
Sacramento, plus Stockton	7	12.4	0.35	67.4	+0.27	59.3		
San Joaquin, Fresno and south	9	15.4	1.93	81.2	+0.89	95.6	13.0	33
Sacramento, plus north of Fresno	9	13.5	0.89	63.9	+0.45	62.5		
San Joaquin, south of Fresno	5	16.9	2.03	85.8	+0.95	103.2	15.7	44
Sacramento, plus Fresno and north	13	13.5	1.68	58.0	+0.63	69.8		
All urban sites	11	18.9	2.54	51.0	+0.61	80.0	17.1	61
All rural sites	7	7.5	2.32	67.7	+0.64	77.6		
San Joaquin Valley, distance from Stockton gradient	12	15.5	1.99	73.8	+0.76	varies by site	8.9	17
Sacramento Valley	6	12.5	0.35	66.8	+0.28	58.7		

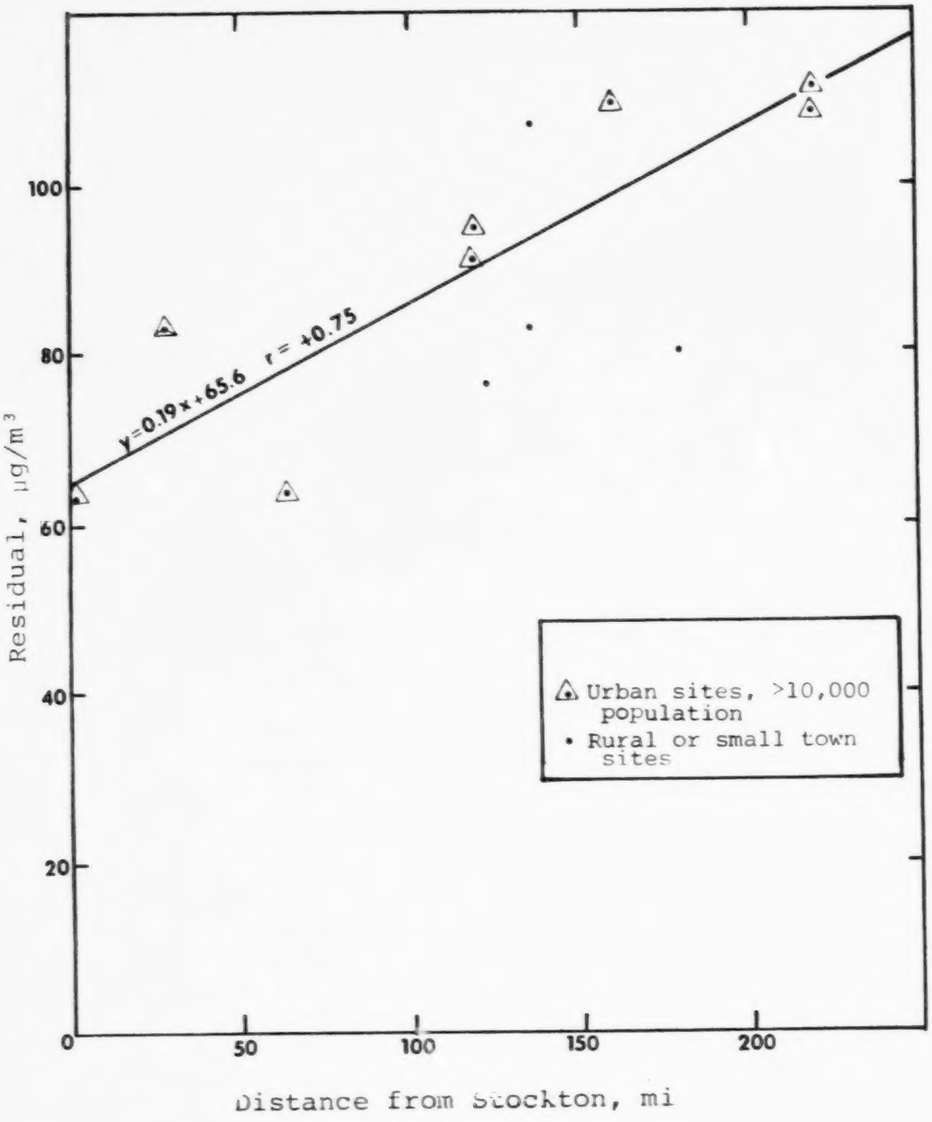

Figure 6-3. Residual versus distance from Stockton.

- The residual for the San Joaquin Valley sites becomes unusually high in the southern portion of the valley.
- The root mean error for the California sites is equivalent to and, in some cases, better than that for other studied areas.
- The percent of California sites outside the standard error of the model is acceptable.

When the corrected residuals for the two groups are added to the concentrations predicted by the basic empirical equation and the sums are compared with measured concentrations, a linear regression equation of $y = 1.05x - 4.8$, where $r = +0.90$ is produced, and 14 of the 18 sites affected are within the standard error of the model.

For most sites, the major contributor to the concentration explained by the model is the AREA term (see Tables 6-5 and 6-6). Averages of 11.1 and 8.2 $\mu g/m^3$ are contributed by that term in the San Joaquin and Sacramento Valleys. The LOCAL term is the next greatest contributor at most sites, producing averages of 5.0 and 5.4 $\mu g/m^3$ in those two site groupings. The POINT term contributes negligible amounts at all sites except Fort Bragg, where 6.6 $\mu g/m^3$ is produced by that term. The VISPLUME term was not assigned at any of the sites.

From the data presented thus far, four questions emerge:

- Why is the contribution from sources in the microinventory area so small relative to that found in other parts of the country?
- Why is there such a gradient to the calculated residuals in the San Joaquin Valley sites?
- Why was such a poor correlation obtained for the nine Sacramento Valley sites?
- Why are certain sites outside the standard error of the model?

In response to the first question, there are not enough emissions being generated in the immediate vicinity of the California sites. All four terms specified in the empirical model show significantly lower contributions than are shown in other cities and areas studied. For the most part, this is simply a function of the small size of the cities and towns microinventoried in California. The general lack of significant point sources is another probable explanation.

TABLE 6-5. CONTRIBUTIONS FROM COMPONENTS

($\mu g/m^3$)

Site	AREA	POINT	LOCAL	VISPLUME	Residual
Bakersfield (Flower)	10.9	0.3	8.6	0.0	107.4
Bakersfield (Chester)	21.9	0.1	8.0	0.0	107.4
Taft[a]	27.0	0.0	12.8	0.0	
Kern Refuge	1.6	0.0	0.0	0.0	99.8
Kettleman City[a]	8.9	0.0	3.0	0.0	
Visalia	10.0	0.0	9.9	0.0	96.0
Parlier	11.5	0.0	3.4	0.0	91.4
Fresno (Olive)	16.9	0.0	11.7	0.0	88.4
Fresno (Cal State)	11.5	0.0	2.7	0.0	88.4
Five Points	10.9	0.0	0.0	0.0	89.2
Coalinga	2.2	0.1	0.0	0.0	91.4
Merced	13.1	0.0	1.9	0.0	77.8
Modesto (J St)	10.6	0.4	9.2	0.0	70.9
Stockton	9.8	0.2	2.6	0.0	65.6
Sacramento (P St)	10.7	0.3	6.8	0.0	58.7
Woodland	8.7	0.1	0.0	0.0	58.7
Sutter City	1.6	0.2	5.6	0.0	58.7
Live Oak	4.5	0.0	8.7	0.0	58.7
Chico	10.7	0.3	14.2	0.0	58.7
Red Bluff	4.2	0.5	0.0	0.0	58.7
Fort Bragg[a]	7.6	6.6	9.6	0.0	
Paso Robles[a]	10.8	0.0	11.5	0.0	
Average	9.5	0.5	5.7	0.0	

[a] Excluded from averages.

TABLE 6-6. CONTRIBUTIONS FROM COMPONENTS

(percent)

Site	AREA	POINT	LOCAL	VISPLUME	Residual
Bakersfield (Flower)	8.6	0.2	6.8	0.0	84.4
Bakersfield (Chester)	16.0	0.1	5.8	0.0	78.1
Taft[a]					
Kern Refuge	1.6	0.0	0.0	0.0	98.4
Kettleman City[a]					
Visalia	8.7	0.0	8.6	0.0	82.7
Parlier	10.9	0.0	3.2	0.0	85.9
Fresno (Olive)	14.5	0.0	10.0	0.0	75.5
Fresno (Cal State)	11.3	0.0	2.6	0.0	86.1
Five Points	10.9	0.0	0.0	0.0	89.1
Coalinga	2.4	0.1	0.0	0.0	97.5
Merced	14.2	0.0	2.1	0.0	83.7
Modesto (J St)	11.7	0.4	10.1	0.0	77.8
Stockton	12.6	0.3	3.3	0.0	83.8
Sacramento (P St)	14.1	0.4	8.9	0.0	76.6
Woodland	13.0	0.1	0.0	0.0	86.9
Sutter City	2.4	0.3	8.5	0.0	88.8
Live Oak	6.3	0.0	12.2	0.0	81.5
Chico	12.8	0.4	17.0	0.0	69.8
Red Bluff	6.7	0.8	0.0	0.0	92.5
Fort Bragg[a]					
Paso Robles[a]					

[a] Contributions not calculated owing to lack of measured data or corrected predictions.

The second question can be partially answered by noting that there appears to be a large contribution from secondary particulates and/or mechanically-entrained fugitive dust that is exacerbated by the unusually high incidence of calm wind conditions in the southern part of the San Joaquin Valley.

The third question, regarding the poor correlation obtained for the Sacramento Valley sites, is best explained by looking at the distribution of measured and predicted values and at the root mean error. Measured values range from 59.4 to 87.1 $\mu g/m^3$ and predicted values range from 63.0 to 76.5 $\mu g/m^3$. These ranges reduce the utility and meaningfulness of the correlation statistic. When the average measured and predicted values (71.2 and 71.2 $\mu g/m^3$) and the root mean error (8.3 $\mu g/m^3$) are examined, it becomes obvious that the model is actually predicting reasonably well for those sites.

The last question applies to Kern Refuge, Parlier, and Live Oak where corrected residuals of -18.8, 15.8, and 15.6, respectively, were noted. Recognizing that the true sources of error may lie in the emission factors or field microinventories, the following explanations are suggested:

- Kern Refuge overpredicts because it is not being subjected to the quantity of nonlocalized impact suggested by the distance from the Stockton gradient. This may imply that the gradient represents secondary particulates formed downwind of the several cities located northwest to southeast from Stockton to Bakersfield.
- Parlier underpredicts because it is being impacted by secondary particulates generated in Fresno.
- Live Oak underpredicts either because there is a significant source nearby but outside the 1-mile radius circle or because there are problems with the sampling data obtained from that site.

CONCLUSIONS

The microinventory/empirical particulate model approach discussed in this section suggests that only 2 to 30 percent of the concentrations measured at the inventoried sites can be explained by sources in the immediate vicinity of those sites. Point sources have, with the exception of Fort Bragg, no significant impact. The remaining 70 to 98 percent is contributed by external sources--natural background, secondary particulates, and (according to the statistical data presented in Section 3) dust mechanically entrained by sources fairly close to the sampling sites but outside the 1-mile radius circles.

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SECTION 7

DEFINITION OF THE TSP PROBLEM AT REPRESENTATIVE SAMPLING SITES

INTRODUCTION

Section 2 outlines the methodology that was planned for use in synthesizing the data that were subsequently reported in Sections 3, 4, 5 and 6. The key components of that synthesis are, first, the construction of site specific mass balances on the basis of microscopic, chemical/elemental, and empirical particulate model data; second, an estimation of the percent of TSP contributed by selected source categories; and, third, a comparison of the hypothetical source contributions with observed TSP, microscopic, chemical, elemental, and empirical model statistics. From this synthesis, a definition of the TSP problem in the nonattainment areas investigated in this report will emerge.

MASS BALANCES

The fundamental assumption of the mass balance technique is that the material collected on hi vol filters is comprised of several components which, although measured by different methods, together account for all the particulate matter. The identifiable components are not the same as the contributing source categories, so the conversion from measured components to contributing source categories involves some additional assumptions. The components that should account for 100 percent of the material are:

- Sulfates
    - Secondary
    - Mineral
- Nitrates
- Total carbonaceous materials
    - Carbonaceous combustion products
    - Organic industrial emissions
    - Secondary organics
    - Biological materials
    - Other (rubber, peat, carbonates, etc.)
- Soil minerals
    - Fugitive dust emissons
    - Natural background (mineral)

Inorganic combustion products
Inorganic process emissions
Salts

Each of the above components can be quantified (as a percent of the weight of a sample) by at least one of the three analysis methods described in previous sections--scanning electron microscopy (SEM), chemical/elemental analysis, or microinventory/empirical modeling. Some components can be estimated by two of these methods, thus providing a check on the values obtained. The methods used to estimate each component are summarized in Table 7-1.

The foundation of this mass balancing procedure is the microscopy data presented in Table 4-1. But, in recognition of the fact that some TSP matter was lost by the SEM sample preparation procedure, the percentages given in Table 4-1 are corrected by a factor of $(100\text{-SO}_4^-\text{-NO}_3^-)$.

There are several limitations to the accuracy of this data synthesis technique, besides the process of adding results from different analysis methods, and the method used to obtain microscopy percents. First, and most importantly, average concentrations and percentages are from very small data sets (6 samples for microscopy, <25 samples for chemical/elemental). This greatly increases the uncertainty surrounding the values produced.

Second, the three analyses are performed on data subsets which are representative of different time periods. This could not be avoided given the problems noted in Section 5.

Third, BSO and NO_3^- concentrations could not be directly determined for the samples. In the case of BSO, this was because of chemical reactions on the stored filters. In the case of NO_3^-, it was caused by deficiencies in the method of sampling and analysis. Concentrations of BSO and NO_3^- were estimated indirectly for each of the Phase I sites from BSO and NO_3^- data generated by ARB at nearby sites. It was assumed that the ratios between SO_4^- concentrations and each of these two chemicals would be constant between the Phase I site and the nearby ARB site. The ratios used in this exercise are shown in Table 7-2.

Fourth, there were significant differences between the amounts of total carbonaceous material estimated by the total C analysis (assuming that elemental C contributed ~50 percent of the total carbonaceous material) and the SEM technique. Particle misidentification under the microscope was unlikely because energy dispersive X-ray analysis was used to identify the composition of individual particles in the field. Therefore, two alternative values are shown in Table 7-3 to represent the range of carbonaceous material present at each site.

TABLE 7-1. METHODS USED TO ESTIMATE COMPONENT CONTRIBUTIONS TO MASS BALANCE

Component	Estimation method	Validity assessment method	Comments
Water soluble $SO_4^=$	Wet chemical analysis ($Ba/SO_4^=$ turbidimetry)	Statistical analysis of replicate samples	Filter storage may have caused change from original concentration
Total $SO_4^=$	3 (S); S determined by X-ray fluorescence (XRF) analysis	Statistical analysis of replicate samples	Assumes that all measured S is in the form of $SO_4^=$
Mineral $SO_4^=$	3 (S) water soluble $SO_4^=$		Assumes that only mineral $SO_4^=$ are not soluble in water
Total NO_3^-	Ratio of ARB NO_3^- to $SO_4^=$ at nearby sites		Relatively large potential source of error due to NO_3^- sampling/analysis problems and size of ratio (∿2)
Total carbonaceous material	Percent of mass found by SEM (adjusted to account for $SO_4^=$ and NO_3^- lost by the sample preparation method); GC/MS[a] analysis for elemental C (converted to total carbonaceous by applying factor of 1:0.52)	SEM percent should be higher than GC/MS[a] total C by factor of ∿2	Small number of samples used in both methods of analysis; actual amount of material lost in the SEM preparation process is unknown
Secondary organics	Ratio of ARB BSO to $SO_4^=$ at nearby sites	Should be ∿30-50 % of total carbonaceous material	Same as for NO_3^-
Other carbonaceous	Total carbonaceous secondary organics		SEM analysis was not detailed enough to provide more precise resolution

(continued)

TABLE 7-1 (continued).

Component	Estimation method	Validity assessment method	Comments
Soil minerals	Percent of mass found by SEM adjusted to account for lost $SO_4^=$ and NO_3^-, minus mineral $SO_4^=$		
Fugitive dust	Fugitive dust portion of LOCAL and AREA component empirical model contributions		
Natural mineral background	Soil minerals minus fugitive dust	Should be >30 μg/m^3	Local versus long-range origin should be related to particle size
Inorganic combustion products	Pb + Br + V + Ni from XRF analyses	Statistical analysis of replicate samples; this should approximately equal the nonfugitive dust LOCAL and AREA contribution found by empirical particulate model	
Inorganic process emissions	POINT contribution found by empirical particulate model		
Salts	Percent of mass found by SEM adjusted as in the case of soil minerals		

[a] GC/MS = gas chromatography/mass spectrometry

TABLE 7-2. MULTIPLIER USED TO ESTIMATE NITRATE AND SECONDARY ORGANIC CONCENTRATIONS

	$SO_4^{=}$	
Site	NO_3^-	BSO
Bakersfield (Flower)[a]	1.5	1.0
Taft[a]	1.5	1.0
Kern Refuge[b]	1.8	1.3
Visalia[c]	2.6	1.9
Parlier[d]	2.6	1.9
Fresno (Cal State)[d]	2.6	1.9
Five Points[e]	2.8	1.6
Merced[f]	2.8	1.3
Modesto (J St)[g]	2.8	1.3
Woodland[h]	1.7	1.3
Live Oak[i]	1.8	1.3
Chico[j]	1.8	1.3
Fort Bragg[k]	0.2	0.9
Paso Robles[k]	0.9	0.9

[a] 1976 Bakersfield (Chester) ratios.
[b] Assumed to be equal to the average of Bakersfield (Chester) and Visalia ratios.
[c] Average of 1976 Bakersfield (Chester) and Fresno (Olive).
[d] 1976 Fresno (Olive) ratios.
[e] Average of 1976 Madera and Fresno (Olive) ratios.
[f] 1976 Merced (18 & S) ratios.
[g] 1976 average of Merced (18 & S) and Madera ratios.
[h] 1976 Sacramento (P St) ratio.
[i] Average of 1976 Sacramento (P St) and Red Bluff ratios.
[j] 1976 Red Bluff ratio.
[k] 1977-1978 ratios.

TABLE 7-3. PERCENT OF AVERAGE MASS BY COMPONENT AT PHASE I SITES

Component	Percent of mass by site							
	Bakersfield (Flower)	Parlier	Fresno (Cal State)	Merced	Modesto (J St)	Woodland	Live Oak	Chico
Water soluble $SO_4^=$	7.6	5.3	4.0	4.8	4.4	3.5	3.3	2.4
Mineral $SO_4^=$	4.2	1.3	3.6	7.0	1.5	1.8	0.7	7.3
Total NO_3^-	11.4	13.8	10.4	13.4	12.3	6.0	5.9	4.3
Secondary organics (BSO)	7.6	10.1	7.6	6.2	5.7	4.6	4.3	3.1
Other carbonaceous	3.2-6.7	(3.4) 15.4	1.6-19.4	7.6-14.6	3.9-8.2	6.0-12.1	7.2-9.3	4.0-8.7
Fugitive dust	12.8	11.8	12.9	20.9	16.4	11.5	13.1	29.4
Mineral background	49.5	42.2	32.8	33.1	51.5	60.8	63.4	44.8
Inorganic combustion products	1.3	0.2	1.1	1.1	0.8	0.3	0.4	1.0
Inorganic process emissions	0.2	0.0	0.0	0.0	0.4	0.1	0.0	0.4
Salts	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0
Total	97.8-101.3	81.3-100.1	74.8-92.6	94.1-101.1	96.9-101.2	94.6-100.7	98.3-100.4	96.7-101.4

Fifth, microscopy was unable to distinguish among different carbonaceous materials to the extent anticipated in the study design. As a result, all carbonaceous material, except BSO (assumed to broadly represent secondary organics), has been combined into a component termed "other carbonaceous."

Table 7-3 summarizes the mass balances that were produced for each of the Phase I sites. Mass balances could not be computed for Phase II sites owing to the lack of microscopy data. Five facts are apparent about the computed mass balances:

- Extreme differences in the other carbonaceous component at Parlier and Fresno (Cal State) cause the totals for these sites to exhibit rather broad ranges. The data do not indicate which other carbonaceous fractions are more correct.

- Mineral background is by far the largest component, followed rather distantly by fugitive dust and the individual secondary aerosol components.

- Secondary aerosols are much smaller contributors in the Sacramento Valley than they are in the San Joaquin Valley.

- The relatively larger mineral $SO_4^=$ components suggest that greater numbers of S-rich particles should have been found by SEM, or that the computed mineral $SO_4^=$ concentrations are somewhat greater than those actually present.

- Only a maximum of 93 percent of the mass was accounted for at Fresno (Cal State). This results from the deletion of the SEM metal percent. Comparison with V, Br, Pb, and Ni concentrations and empirical particulate model predictions clearly indicate that these percents are anomalous.

ESTIMATED SOURCE CONTRIBUTIONS

Contributions of selected sources to TSP concentrations measured at Phase I sites were calculated through manipulation of the mass balance data given in Table 7-3. Because mass balances could not be computed for Phase II sites, it was necessary to devise an alternative procedure.

Five source categories are stipulated: (1) natural background plus regional sources (defined to represent such activities as agricultural tilling, wind erosion of croplands, fertilizer and pesticide application, agricultural burning, and cotton gins operations); (2) man-related secondary aerosols; (3) local point sources; (4) local fugitive dust; and (5) other local sources. Conversion of mass balance data to contributions from these five source categories necessitated the following set of assumptions:

- All water soluble $SO_4^{=}$ are secondary aerosols.
- All mineral $SO_4^{=}$ are attributable to regional sources and natural background.
- All NO_3^{-} are secondary.
- All other carbonaceous material is attributable to regional sources and natural background.
- The V and Ni portion of inorganic combustion products is attributable to local point sources.
- All industrial process emissions are attributable to local point sources.
- Salts are a part of natural background.
- The Pb and Br portion of inorganic combustion products is attributable to other local sources.

Given this set of assumptions, the source contributions listed in Table 7-4 can be calculated. According to that table, there are only three source categories that have a significant impact upon Phase I sites: natural background and regional sources, man-related secondary aerosols, and local fugitive dust. The first of these has by far the greatest effect, ranging from 39 to 75 percent of the TSP measured at those eight sites. The next most significant source, secondary aerosols, ranges from 10 to 29 percent of TSP and shows a distinctly greater effect at the San Joaquin Valley sites than at the ones in the Sacramento Valley. Local fugitive dust generally contributes ∿15 percent of the measured TSP. Local point sources and other local sources are estimated to contribute no more than 1 percent of the measured TSP at any of the eight sites.

Phase II site source contributions must be calculated somewhat differently because microscopy data are not available for them. Local point, local fugitive dust, and other local source contributions were extracted directly from the empirical particulate model values, with the contribution from fugitive dust sources being separated from the AREA and LOCAL terms. Man-related secondary aerosol contributions were calculated in the same manner as the calculations made for the Phase I sites. The contribution of natural background and regional sources was

TABLE 7-4. ESTIMATED SOURCE CONTRIBUTIONS AT PHASE I SITES

	Source contribution, %								
Source	Bakersfield (Flower)	Parlier	Fresno (Cal State)	Merced	Modesto (J St)	Woodland	Live Oak	Chico	Extremes
Natural background and regional	57-60	40-59	39-57	48-55	57-61	69-75	71-73	56-61	39-75
Man-related secondary aerosols	27	29	22	24	22	14	14	10	10-29
Local point	<1	<1	<1	<1	1	<1	<1	1	<1-1
Local fugitive dust	13	12	13	21	16	12	13	29	12-29
Other local	1	<1	1	<1	1	<1	<1	1	<1-1
Total	98-101	81-100	75-93	94-101	97-101	95-101	98-100	97-101	75-101

computed by subtracting the aforementioned contributions from 100. Table 7-5 summarizes the estimated source contributions resulting from this process. It should be noted that the estimated source contributions for Taft are highly suspect owing to the apparent sampling site bias reported in Section 6.

COMPARISON OF SOURCE CONTRIBUTION ESTIMATES WITH OTHER DATA

Perhaps the best way to view the source contributions given in Tables 7-4 and 7-5 is as hypothetical constructs that need to be evaluated in terms of available empirical data. Fortunately, a wealth of such data was presented in Sections 3, 4, 5, and 6. In this subsection those data will be summarized, compared to the hypothetical source contributions, and used to assess the overall accuracy of those contributions. A summary paragraph is presented for each site. The summary paragraph sequentially presents information concerning long-term trends; quarterly and daily patterns; relationships between TSP and days since significant precipitation, and between TSP and average wind speed; intersite correlations, and the degree to which 24-h NAAQS violations at the subject site are region-wide in nature; amounts of various particle types observed with SEM; amount of variance in TSP explained by the microinventory/empirical particulate model; and amount of secondary particulate matter associated with each site. Table 7-6 summarizes the characteristics that are expected to be associated with various source categories.

Qualitative terms, rather than exact numbers, are used to describe the amounts or percentages associated with various components. This is done to convey a sense of the inexactitude of the data involved. Table 7-7 itemizes the ranges associated with each qualitative term.

Bakersfield (Flower)

The following conditions were observed: a slight trend toward decreasing concentrations over the past seven years; concentrations that steadily increase from the first through fourth quarters; no significant daily patterns; increasing concentrations with drier soils; decreasing concentrations with increasing wind speeds; very good covariance with other Bakersfield sites, but only fair covariance with other sites in the region; a very large amount of >2.0 μm mineral particles, moderate amounts of >2.0 μm carbonaceous particles, very small amounts of <2.0 μm mineral and carbonaceous particles; a large percentage of TSP variance explained by soils, a moderate amount by crude oil, a small amount by autos, a very small amount by other factors, and a small amount unexplained; a small amount of TSP explained by local microinventoried sources, and a very large amount unexplained; very large amounts of secondary particulate matter.

TABLE 7-5. ESTIMATED SOURCE CONTRIBUTIONS AT PHASE II SITES

Source	Source contribution, %					
	Taft[a]	Kern Refuge	Visalia	Five Points	Fort Bragg	Paso Robles
Natural background and regional	34	66	67	62	68	50
Man-related secondary aerosols	27	22	17	25	8	17
Local point	0	0	0	0	7	0
Local fugitive dust	36	2	14	13	15	29
Other local	3	0	2	0	2	4
Total	100	100	100	100	100	100

[a] Highly suspect due to sampling site bias.

TABLE 7-6. CHARACTERISTICS USED TO ASSESS HYPOTHETICAL SOURCE CONTRIBUTIONS

	Data characteristics								
Source	Long-term trends	Temporal patterns	Regional TSP violations	Precip-itation	Wind speed	Wind direction	Particle types	Factor analysis	Empirical model
Natural background and regional	Heavily impacted sites will covary	Highest TSP in summer	Heavily impacted sites will be region-wide	Highest TSP when dry	TSP directly proportional to wind speed	No effect	Smaller mineral particles more prevalent	Large % of variance from soils	Large residual
Man-related secondary aerosols	No effect unless SO_2 and NO_x emissions change	Highest TSP in fall, inversion conditions	Heavily impacted sites will be region-wide	Highest when air is moist, but no precip-itation	TSP inversely propor-tional to wind speed	No effect	Smaller C particles more pre-valent	Large % of variance from $SO_4^=$	Large residual
Local point	Directly proportional to source emissions	Function of source operations	Heavily impacted sites will not be region-wide	No effect	TSP inversely propor-tional to wind speed	Pollution rose will point out sources	Dependent on source type	Distinct factor will emerge	Large POINT contri-bution
Local fugitive dust	Directly proportional to road paving and traffic volume changes	Highest TSP in summer	Function of regional precipitation patterns	Highest TSP when dry	TSP directly proportional to wind speed	Pollution rose may point out sources	Larger mineral particles will pre-dominate	Large % of variance from soils	Large AREA and LOCAL contribu-tion
Other local	Directly proportional to traffic volumes and fuel use trends	Highest TSP during fall, inversion conditions	Heavily impacted sites will not be re-gion-wide	No effect	TSP inversely propor-tional to wind speed	Pollution rose may point out sources	Larger C particles will tend to pre-dominate	Large % of variance from auto or other factor	Large AREA and LOCAL contri-bution

TABLE 7-7. QUALITATIVE TERMS USED IN DERIVING SOURCE CONTRIBUTIONS

Term	Microscopy, %	Factor analysis %	EPM, %	Secondary, %
Very large	>75	>50	>75	>20
Large	50-74	30-49	50-74	15-19
Moderate	25-49	20-29	25-49	10-14
Small	10-24	10-19	10-24	5-9
Very small	0-9	0-9	0-9	0-4

These data support the hypothetical source contributions given in Table 7-4.

Taft

The following conditions were observed: insufficient data to compute long-term trends; a very slight but steady increase in concentrations through the year; no significant daily patterns; good correlations with the few nearby sites; a very large percent of variance in TSP explained by soils, a moderate percent by fuel oil, and a very small percent unexplained; apparent bias in the sampler site location; a moderate amount of TSP explained by local microinventoried sources, and a large amount unexplained; very large amounts of secondary particulate matter. Meteorological and microscopy data were not available.

There is nothing about these data that contradict the contributions given in Table 7-5; however, it must be stressed that these contributions are largely based on data that are apparently biased by the current location of the hi vol sampler.

Kern Refuge

Conditions at Kern Refuge were observed to be as follows: a long-term pattern of stable concentrations; a steady increase in concentrations throughout the year, modified slightly by a somewhat elevated first quarter; low Sunday concentrations; mostly good correlations with nearby sites; a very large percent of variance in TSP explained by fuel oil, very small percents explained by other factors, a moderate percent unexplained by other factors, and a moderate percent unexplained; a very small percent of TSP explained by local microinventoried sources, and a very large amount unexplained. No meteorological, microscopy, or chemical data were available for this site.

The very small percent of variance explained by soils appears to contradict the soil contribution given in Table 7-5. This may simply reflect the fact that factor analysis explains variance and not absolute levels, or it may reflect the lack of secondary particulate data for the site. The site is very interesting and deserves intensive analysis.

Visalia

The following conditions were observed: considerable fluctuation in concentrations over time, but no apparent trend; a steady increase in concentrations throughout the year; no significant daily patterns; fair to very good correlations with nearby sites; approximately half of the observed violations occurring on region-wide days; a very large percent of variance in TSP explained by soils, very small percents by other factors, and a moderate percent unexplained; a small amount of TSP explained by local microinventoried sources, and a very large amount unexplained; a very large amount of secondary particulate matter. No meteorological or microscopy data were available for this site.

These data are supportive of the source contributions given in Table 7-5.

Parlier

The following conditions were observed: a steady trend toward increasing concentrations over the past seven years; concentrations that display an inverted-U seasonal pattern, with concentrations reaching their maxima in the summer; no significant daily patterns; increasing concentrations with increasingly drier soil; concentrations that are not variant with wind speed; good covariance with most other sites in the region; large amounts of large mineral particles, moderate amounts of large carbonaceous particles, small amounts of small mineral particles, and very small amounts of small carbonaceous particles; a very large percentage of variance in TSP explained by soils, small amounts by $SO_4^=$ transport and an unidentified S/Br source, very small amounts by dry soil conditions and maritime air, and a small amount unexplained; a small amount of TSP explained by local microinventoried sources, and a very large amount unexplained; very large amounts of secondary particulate matter.

When compared with data for Bakersfield, these data suggest that the source contribution estimates for Parlier tend to understate the role of natural background and regional sources and to overstate the role of secondary aerosols somewhat. Nevertheless, the source contributions given in Table 7-4 appear to be good approximations of the actual situation.

Fresno (Cal State)

The following conditions were observed: insufficient data to discern a long-term trend; concentrations that steadily increase through the fourth quarter; no significant daily patterns; increasing concentrations with increasingly drier soils; decreasing concentrations with increasing wind speeds; good covariance with all other sites in the region, except for rural sites to the west; violations of the 24-h secondary NAAQS frequently occurring on region-wide days during inversion conditions; moderate amounts of large mineral particles, small amounts of both size fractions of carbonaceous particles, of small mineral particles, and of other particles (especially metals); a large percentage of variance in TSP explained by soils, a moderate amount by $SO_4^=$ inversions, a small amount by automotive traffic, a very small amount by maritime air, and a small amount unexplained; a small amount of TSP explained by local microinventoried sources, and a very large amount unexplained; very large amounts of secondary particulate matter.

The relatively large amounts of small carbonaceous particles and metal particles found by DRI at this site are not completely consistent with the source contribution table. Because small carbonaceous and metal (Pb) particles are indicative of automotive emissions, it would be logical to find at least a moderate percentage of variance in TSP explained by the auto factor and to find a significant amount of automotive emissions within the 1-mile radius microinventory area. Neither of these findings were obtained. Further, an investigation of the microscopy data (see Table 4-5) indicates that the average particle type contributions for this site were strongly affected by conditions existing on one day (December 20, 1976) and that these conditions may well have been anomalous. It would appear that the percent contributions given in Table 7-4 should be increased by a factor of ∿1:0.93.

Five Points

Conditions at Five Points were observed to be as follows: a steady increase in TSP concentrations over the past seven years; a steady increase in concentrations through the year; low Sunday concentrations; fair to good correlations with nearby sites; violations generally observed not to occur on region-wide days; a very large percent of TSP variance explained by soils, very small percents by other factors, and a moderate percent unexplained; a small amount of TSP explained by local microinventoried sources, and a very large amount unexplained; a very large amount of secondary particulates. No meteorological or microscopic analyses were performed for this site.

These data imply that there is a soil-related source category, relatively nearby, whose emissions have been steadily increasing over the past seven years. This is generally consistant with the Table 7-5 data, but may suggest that the secondary contribution listed in that table is somewhat excessive.

Merced

The following conditions were observed: insufficient data to discern a long-term trend; concentrations that steadily increase through the fourth quarter; no significant daily patterns; a very good degree of covariance with data from other sites in the region; violations of the 24-h secondary NAAQS frequently occurring on region-wide days during inversion conditions; large amounts of large mineral particles, small amounts of large carbonaceous particles, and very small amounts of small mineral and carbonaceous particles; a very large percentage of variance in TSP explained by automotive traffic, a small amount by soils, very small amounts by fuel oil and wind speed, and a small amount unexplained; a small amount of TSP explained by local microinventoried sources, and a very large amount unexplained; very large amounts of secondary particulate matter.

The apparent discrepancy between Merced's source contribution table and the amount of TSP variance is best explained by recalling that California Highway 99 is an elevated, multilane roadway located in a semi-circular pattern ∿500 feet north of the sampling site. Thus, the automotive factor can be interpreted as being a reentrained dust/auto exhaust factor. The data in Table 7-4 generally confirm the source contribution estimates.

Modesto (J St)

The following conditions were observed: insufficient data to discern a long-term trend; concentrations that steadily increase through the fourth quarter; no significant daily patterns; a good degree of covariance with data from other sites in the region; violations of the 24-h secondary NAAQS frequently occurring on region-wide days during inversion conditions; very large amounts of large mineral particles, small amounts of large mineral particles, small amounts of large carbonaceous particles, and very small amounts of the small-size fraction particles; large percentages of variance in TSP explained by automotive traffic and soils, small percentages by maritime air and an unidentified Al source, and a small percentage unexplained; a small amount of TSP explained by local microinventoried sources, and a very large amount unexplained; very large amounts of secondary particulate matter.

These data do not detract from the estimated source contributions in Table 7-4.

Woodland

The following conditions were observed: insufficient data to discern a long-term trend; concentrations that steadily increase through the fourth quarter; no significant daily patterns; a good degree of covariance with data from other sites in the region; large amounts of large mineral particles, small amounts of large carbonaceous particles and small mineral particles, and very small amounts of small carbonaceous particles; very large percentages of variance in TSP explained by soils, a large amount by secondary SO_4^-, small percentages by other minor sources, and a small percentage unexplained; a small amount of TSP explained by local microinventoried sources, and a very large amount unexplained; moderate amounts of secondary particulate matter.

The amount of variance in TSP explained by the $SO_4^=$ factor is somewhat at odds with the source contributions in Table 7-4.

The facts that very small amounts of small carbonaceous particles and only moderate amounts of secondary aerosols were measured suggest that the amount of variance allocated to that $SO_4^=$ factor is somewhat excessive.

The source contribution estimates in Table 7-4 appear reasonable.

Live Oak

The following conditions were observed: insufficient data to compute a long-term trend; concentrations that steadily increase through the fourth quarter, except for an unexpectedly high second quarter concentration; no significant daily patterns; a good degree of covariance with nearby sites, but only fair covariance with other sites in the region; large amounts of large mineral particles, small amounts of large carbonaceous particles, and very small amounts of other particle types; a very large percentage of variance explained by soils, a very small percentage explained by other factors, a moderate amount unexplained; a small amount of TSP explained by local microinventoried sources, and a very large amount unexplained; moderate amounts of secondary particulate matter.

The microscopy and regional analysis data suggest that there is a source of carbonaceous material near Live Oak but outside the 1-mile microinventory area, which has a greater effect on TSP concentrations at that site than at Woodland or Chico. That source, probably agricultural burning, could contribute as much as ∿5 percent of the TSP concentrations measured at Live Oak.

Chico

The following conditions were observed: stable concentrations over the past seven years; concentrations that steadily increase through the fourth quarter; no significant daily patterns; a good degree of covariance with other sites in the region; large amounts of large mineral particles, moderate amounts of small mineral particles, small amounts of large carbonaceous particles, and very small amounts of small carbonaceous particles; a large percentage of variance in TSP explained by soils, a moderate percentage by automotive traffic, a very small amount by dry soil conditions, a small amount unexplained; a moderate amount of TSP explained by local microinventoried sources, and a large amount unexplained; small amounts of secondary particulate matter.

The source contributions given in Table 7-4 appear substantially correct. The only likely source of significant error is in the percent contribution attributed to local fugitive dust sources.

Fort Bragg

Data for Fort Bragg were observed to be as follows: insufficient data with which to construct a long-term trend line; maximum concentrations occurring in the second quarter; high Wednesday concentrations; poor correlations with the few nearby sites; a very large percent of variance in TSP explained by a marine air/wood boiler factor, a small percent by soils, very small percents by other factors, and a moderate percent unexplained; a small amount of TSP explained by local microinventoried sources, and a very large amount unexplained; a small amount of secondary particulate matter. No meteorological or microscopy data were available for this site.

These data are consistent with the values listed in Table 7-5. It is possible that the contribution from the Georgia-Pacific facility has been underestimated. This is because there is a lack of good data for the carbonaceous fraction of TSP collected at this site.

Paso Robles

Paso Robles recorded the following sets of data: insufficient data for the computation of long-term trends; generally stable concentrations throughout the year, with a slightly elevated fourth quarter; low Sunday concentrations; a good correlation with a site located in a similar location along the north central coast; a very large percent of variance in TSP explained by soils, and a very small percent unexplained or contributed by other factors; a small amount of TSP contributed by local microinventoried sources, and a very large amount unexplained; a large amount of secondary particulates. No meteorological or microscopic data were available.

The inability to correct the empirical particulate model's predicted concentrations to account for their deviation from measured TSP concentrations (see Section 6) may have caused an overestimate of the contribution from local sources. Otherwise, the Table 7-5 data are confirmed by the above data.

CONCLUSIONS

Nonlocal, soil-related sources (i.e., natural background and regional sources) appear to be the major cause of concentrations observed in the nonattainment areas. Secondary particulates appear to be a significant contributing factor throughout the San Joaquin Valley, but numerous sampling and analysis problems render that conclusion somewhat problematical. Crude-oil, steam generators in the southern part of that valley appear to be the major source of much of the secondary particulate measured there.

Certain sites (e.g., Taft, Merced, Chico, and Paso Robles) appear to be strongly affected by local fugitive dust sources, and all of the special study sites (with the exception of Kern Refuge) are impacted to a significant extent by such sources. Primary particulate emissions from point sources were not found to play a significant role at any site except Fort Bragg. Agricultural burning was not found to be a major contributor at any site, most probably because of the excellent forecasting and permitting system managed by the ARB.

SECTION 8

IDENTIFICATION OF REASONABLY AVAILABLE CONTROL MEASURES

INTRODUCTION

In this section reasonably available control measures (RACM's), which might be applied in the California study areas in order to control sources of particulate matter, are identified. Traditional sources for which RACM's were investigated include industrial sources of TSP emissions that are currently required to obtain permits to operate, and direct support operations for these sources. Direct support operations include process fugitive emissions, and fugitive emissions covered by general good housekeeping practices.

The regulations currently in effect in California are generic type measures and not industry-specific. The RACM's investigated are the generic type, as this is consistent with current practices. Specific industry regulations were not considered. The existing controls in California (South Coast, San Diego, and Bay Area Air Basins) were reviewed to determine the most stringent rules now in effect in the state. In addition, regulations throughout the country were evaluated to see if more stringent regulations exist elsewhere. The results of this investigation are presented below.

A summary of existing TSP regulation citations for the study areas in California is given in Table 8-1. Also included in this table are the South Coast, San Diego, and Bay Area Air Basins. Table 8-2 presents the TSP emission limitations for each regulation cited in the first table. This table summarizes the existing regulations in the study area counties, as well as those found in the South Coast, San Diego, and Bay Area regions. Comparison of these regulations to areas outside California are presented in the following subsections.

VISIBLE EMISSIONS

The most stringent regulation currently in effect in California governing visible emissions is a limit of Ringelmann No. 1 (20% opacity). This is also the most common visible emission limit found throughout the country, although some states have

TABLE 8-1. SUMMARY OF PARTICULATE REGULATION CITATIONS

Air basin	County	Visible emissions	Process weight	Grain loading	Fugitive dust	Fuel burning	Combustion contaminants	Power & Steam generators	Incinerators
North Coast	Mendocino	401(b)	420(d)	420(d)	430		420(a)	420(b)	420(e)
South Central Coast	San Luis Obispo	401A	403B	403A		403 C.2.	403 C.1.		
Sacramento Valley	Sacramento	7	21	23	9		24(a)(2)		
	Yuba	2	2.19	2.18			2.18		
	Yolo-Solano	2.3	2.19	2.11		2.16	2.12(b)		
	Butte	2-2	2-4	2-5			2-5		
	Shasta	3:1	3:2	3:2			3:2		
	Sutter	2.3	2.11	2.10		2.15(c)	2.12(b)		
	Tehama	4.1	4.8	4.3		4.13(c)	4.9(b)		
San Joaquin Valley	Fresno	401	405	404		408(a)	408(b)		407(a)
	Kern	401	405	404		408	407.2		407.1
	Kings	401	405,406	404		408	407.2		407.1
	Madera	401	405,406	404		408	407.2		407.1
	Merced	401	405,406	404		408	408.2		407.1
	San Joaquin	401	405,406	404		408	407.2		407.1
	Stanislaus	401	405,406	404		408	407.2		407.1
	Tulare	401	405	404		408	407.2		407.1
South Coast		401	405	404	403		409	475 & 476	473
San Diego		50	54	52			53(b)		53(b) & 53(c)
Bay Area		3110	6112.2	6112.1			5112		4112.1 & 4112.2

TABLE 8-2. SUMMARY OF PARTICULATE EMISSION LIMITATIONS

Air basin	County	Visible emissions	Process weight	Grain loading	Fugitive dust	Fuel burning	Combustion contaminants	Power & Steam generators	Incinerators
North Coast	Mendocino	Ring. 1	Table, ≤40 lb/hr	0.46 g/m^3			0.46 g/m^3	0.23 g/m^3	Ring. 2
South Central Coast	San Luis Obispo	Ring. 2	Table, ≤40 lb/hr	0.3 gr/scf		10 lb/hr	0.3 gr/scf		
Sacramento Valley	Sacramento	Ring. 1	Table, ≤30 lb/hr	0.23 g/m^3	Reason-able pre-caution		0.23 g/m^3		
	Yuba	Ring. 2	Table, ≤92.7 lb/hr	0.3 gr/scf			0.3 gr/scf		
	Yolo-Solano	Ring. 2	Table, ≤40 lb/hr	0.3 gr/scf		40 lb/hr	0.3 gr/scf		
	Butte	Ring. 2	Table, ≤92.7 lb/hr	0.3 gr/scf			0.3 gr/scf		
	Shasta	HSC 41701	40 lb/hr	0.1 gr/scf			0.15 gr/scf		
	Sutter	Ring. 2	Table, ≤92.7 lb/hr	0.3 gr/scf		10 lb/hr	0.3 gr/scf		
	Tehama	Ring. 2	Table, ≤92.7 lb/hr	0.3 gr/scf		10 lb/hr	0.3 gr/scf		
San Joaquin Valley	Fresno	Ring. 1	Table, ≤46.72 lb/hr	0.1 gr/scf		10 lb/hr	0.23 g/m^3		0.23 g/m^3
	Kern	Ring. 1	Table, ≤46.79 lb/hr	0.1 gr/scf		10 lb/hr	0.1 gr/scf		0.1 gr/scf
	Kings	Ring. 1	Table, ≤46.79 lb/hr	0.1 gr/scf		10 lb/hr	0.1 gr/scf		0.1 gr/scf
	Madera	Ring. 1	Table, ≤46.72 lb/hr	0.1 gr/scf		10 lb/hr	0.1 gr/scf		0.1 gr/scf
	Merced	Ring. 1	Table, ≤46.72 lb/hr	0.1 gr/scf		10 lb/hr	0.1 gr/scf		0.10 gr/scf
	San Joaquin	Ring. 1	Table, ≤46.72 lb/hr	0.1 gr/scf		10 lb/hr	0.1 gr/scf		0.1 gr/scf
	Stanislaus	Ring. 1	Table, ≤46.72 lb/hr	0.1 gr/scf		10 lb/hr	0.1 gr/scf		0.1 gr/scf
	Tulare	Ring. 1	Table, ≤46.79 lb/hr	0.1 gr/scf		10 lb/hr	0.1 gr/scf		0.1 gr/scf
South Coast		Ring. 1	Table, ≤30 lb/hr	Table, at max flow =23 mg/m^3 or 0.01 gr/scf	No vis. at prop. line, up-wind/downwind		0.23 g/m^3 or 0.1 gr/scf	11 lb/hr or 0.01 gr/scf	0.1 gr/scf & 0.3 gr/scf
San Diego		Ring. 1	Table, ≤40 lb/hr	0.1 gr/scf			0.23 g/m^3		0.1 gr/scf & 0.2 gr/scf
Bay Area		Ring. 1	Table, ≤40 lb/hr	0.15 gr/scf			0.15 gr/scf		0.15 gr/scf & 0.05 gr/scf

more lenient rules. Three areas were found to have stricter regulations. Georgia, while requiring Ringelmann No. 2 for most sources, allows only 10 percent opacity from new portland cement, nitric acid, or sulfuric acid plants. The District of Columbia allows no visible emissions, with exceptions for minor excursions during start-up or cleaning. The Baltimore Metropolitan and Washington Metropolitan areas of Maryland also allow no visible emissions. Exceptions are permitted when it is demonstrated not practical or technologically infeasible, and for certain sources such as unconfined sources within iron and steel facilities and coke ovens.

PROCESS WEIGHT

The process weight regulation for South Coast Air Basin is the most stringent in the state. Very similar to this regulation and only slightly less stringent, between 2,000 and 20,000 lb/h (process weight), is the Sacramento County rule. Curves relating these two regulations are shown in Figure 8-1.

Also shown in this figure are the San Diego, Bay Area, and Kern County (Valley Basin) regulations. The Kern County regulation is identical to the one used by 10 states. The Bay Area regulation, up to a process weight of 60,000 lb/h, is the same as one used by 29 other states. Above this point, the Bay Area regulation is more stringent. A summary of process weight regulations, by state, is given in Table 8-3.

No regulation is found to be more stringent overall than the California South Coast rule. Two states, however, have regulations that are more stringent at low process weights. The regulation for new sources in Illinois is more restrictive than the South Coast rule at process weights below 25 tons/h, and the Texas regulation is more restrictive below 1.5 tons/h. At process weights above these levels, however, the South Coast regulation is more stringent.

GRAIN LOADING

The overall most stringent grain loading regulation now in effect in California is the South Coast Air Basin rule. This regulation has a sliding scale based on exhaust gas volume, with the minimum allowable concentration at high flow. Below 5,000 scfm, however, the Sacramento, San Diego, or Kern County (Valley Basin) regulation (all 0.1 gr/scf) is more stringent. A comparison of the regulations in effect in California is shown in Figure 8-2.

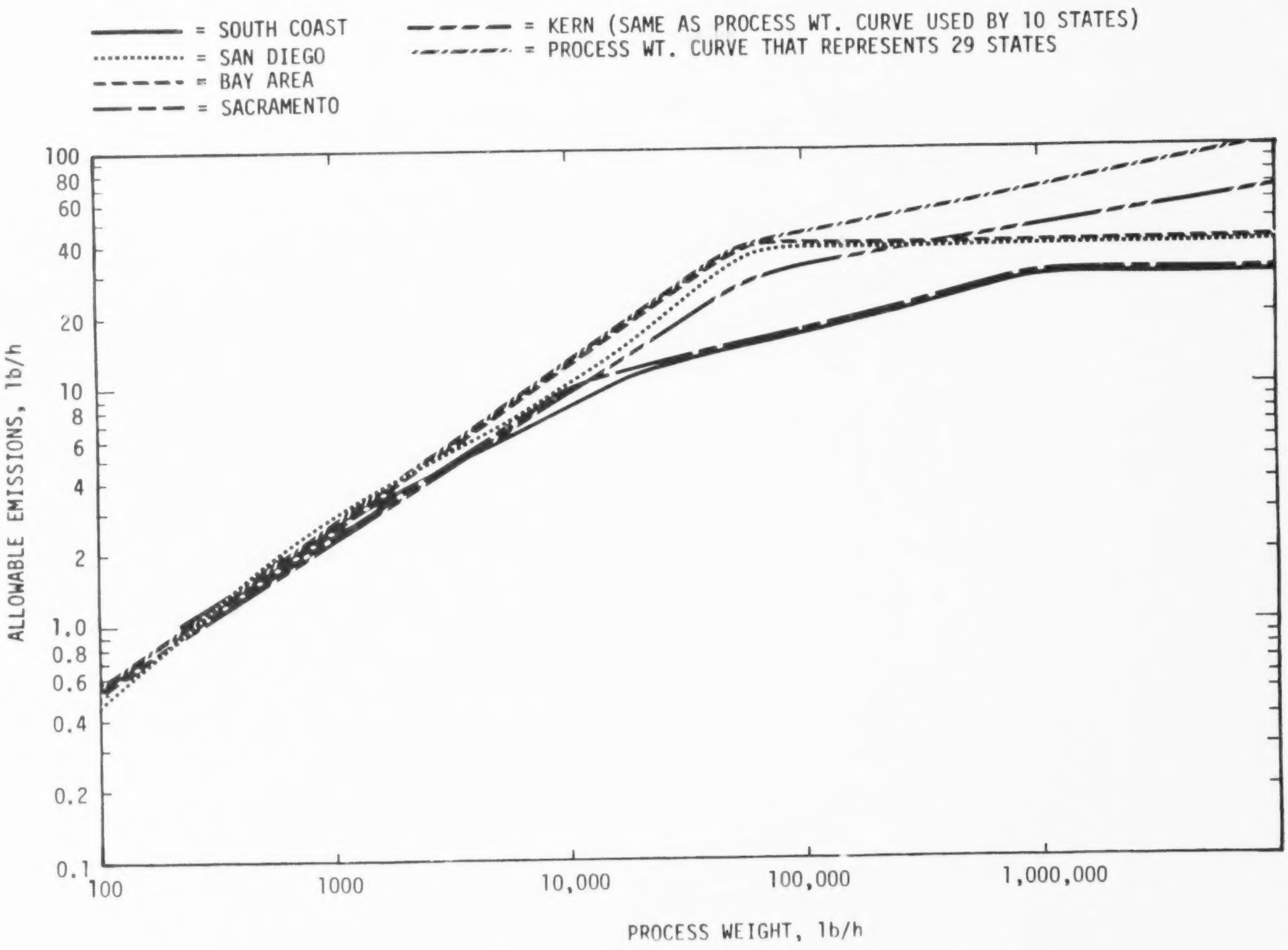

Figure 8-1. Comparison of process weight TSP regulations.

TABLE 8-3. PROCESS WEIGHT, CONCENTRATION, AND OPACITY REGULATIONS BY STATE

State	Process weight equation	Concentration grains/scf	Opacity	Comments
Alabama	a		20	Class 1 counties
	b		20	Class 2 counties
Alaska		0.1	20	Existing source
		0.05	20	New source - July 1, 1972
Arizona	b		40	
Arkansas	a		20	
California				Each county has own regulations
Colorado	a		20	
Connecticut	a		20	
Delaware		0.2	20	
District of Columbia	b (1)		20	Existing source
		0.03	20	New source - January 17, 1972
Florida	a		20	
Georgia	c		10	Existing source
	b		10	New source - July 2, 1968
Hawaii	c		20	
Idaho	b		20	
Illinois	b		30	Existing source
	d		30	New source - December 31, 1972
Indiana	b		40	
Iowa	b		40	
Kansas	b		40	
Kentucky	b	0.02	40	
Louisiana	b		20	
Maine	a		40	
Maryland			20	Same as District of Columbia
Massachusetts	e		20	Existing source
	f		20	New source - June 1, 1972
	f		20	Existing in critical regions
Michigan	b		20	
Minnesota	b	0.3	20	
Mississippi	c		40	
Missouri	b		20	
Montana	b		20	
Nebraska	b		20	
Nevada	b		20	
New Hampshire	g		20	Existing source
	b		20	New source - April 1, 1972
New Jersey			20	
New Mexico		690 µg/m^3	20	Exhaust gas concentrations - Gypsum
			20	
New York		0.3 lb/1000 lb	20	Existing source
		0.05	20	New source - July 1, 1973
North Carolina	b		20	
North Dakota	b		20	
Ohio	b		20	
Oklahoma	b		20	
Oregon	e	0.2	20	Existing source
		0.1	20	New source - February 15, 1972

(continued)

TABLE 8-3 (continued).

State	Process weight equation	Concentration grains/scf	Opacity	Comments
Pennsylvania	h	0.02	60	
Puerto Rico	b		20	
Rhode Island	b		20	
South Carolina	b		20	
South Dakota	b		20	
Tennessee	b		20	Existing source
	a		20	New source - August 9, 1969
Texas	i		20	
Utah			20	85% controlled or opacity laws
Vermont			60	
Virginia	b		20	AQCR 1-6
			20	AQCR 7
Washington		0.2	40	Existing source
		0.1	40	New source - February 2, 1972
West Virginia			20	
Wisconsin	a		20	
Wyoming	b		20	Existing source
	a		20	New source - April 9, 1973

Process weight equation	Less than 30 tons/hr*	Greater than 30 tons/hr*
a	$E = 3.59 P^{0.62}$	$E = 17.31 P^{0.16}$
b	$E = 4.1 P^{0.67}$	$E = 55.0 P^{0.11} - 40$
c	$E = 4.1 P^{0.67}$	(Same as less than 30 tons/hr)
d	$E = 2.54 P^{0.534}$ ***	$E = 24.8 P^{0.16}$
e	$E = 55.0 P^{0.11} - 40$	(Same as less than 30 tons/hr)
f	$E = 1/2\ (55.0 P^{0.11} - 40)$	(Same as less than 30 tons/hr)
g	$E = 5.05 P^{0.67}$	$E = 66.0 P^{0.11} - 48$
h	$E = 0.76 P^{0.42}$ **	(Same as less than 30 tons/hr)
i	$E = 3.12 P^{0.985}$ ****	$E = 25.4 P^{0.287}$

* E units of lbs/hr, P units of tons/hr, except as noted.
** E units of lbs/hr, P units of lbs/hr.
*** Less than 450 tons/hr.
**** Less than 20 tons/hr.
(1) **Greater than 30 tons/hr only.**

Source: Background Information for the Non-Metallic Minerals Industry. PEDCo Environmental, Inc., Cincinnati, Ohio. Prepared for U.S. Environmental Protection Agency. August 1976.

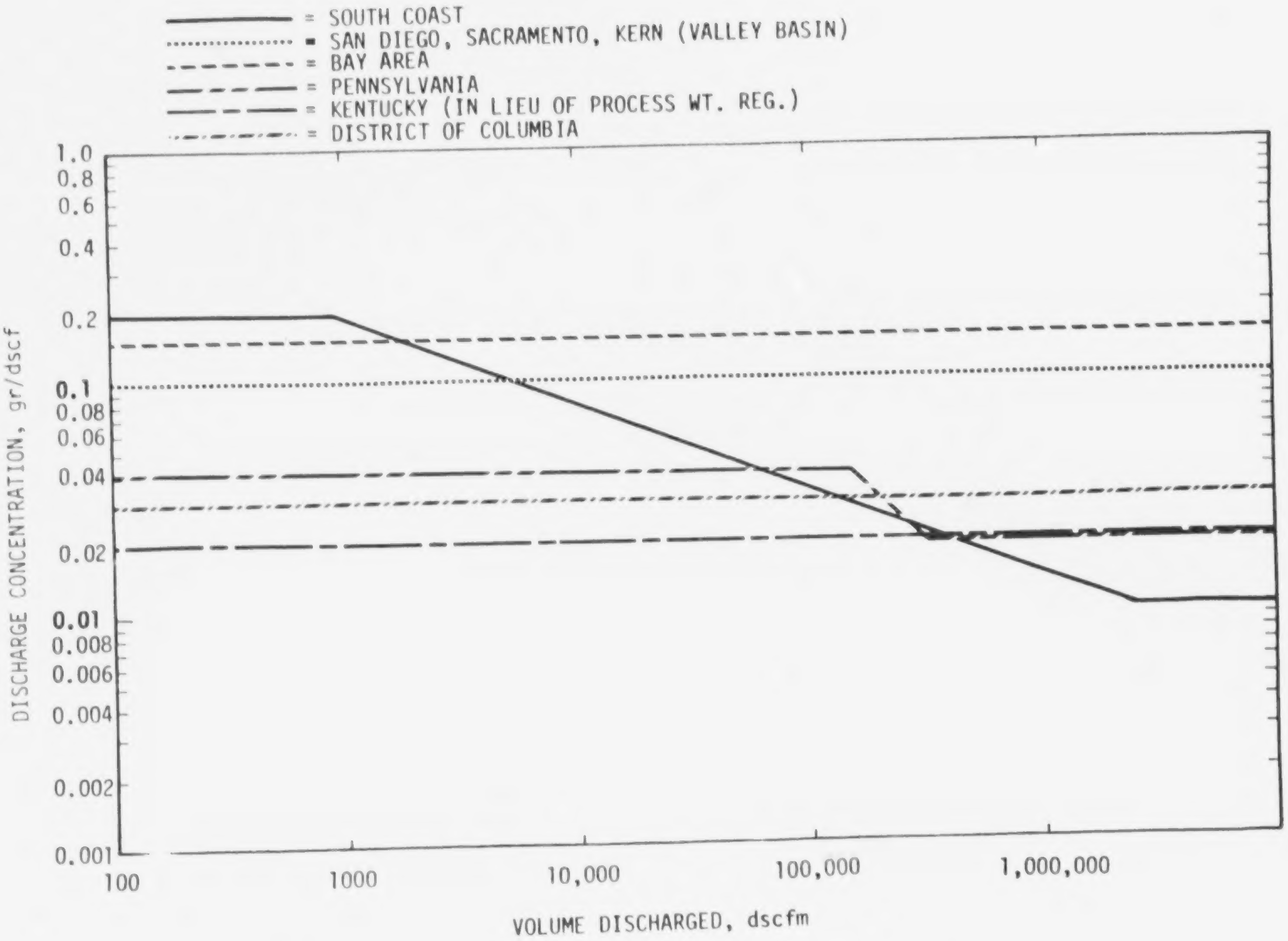

Figure 8-2. Comparison of grain loading (TSP concentration) regulations.

Because of the sliding scale used in the South Coast Air Basin, some areas have allowable concentration regulations that are more stringent at low flows but not at high flows. The District of Columbia allows a maximum of 0.03 gr/scf for all flows. Existing sources in Kentucky are allowed the option of meeting 0.02 gr/scf in lieu of the process weight table. In Pennsylvania, the grain loading regulation applies to sources not covered by rules for 43 specific processes. This regulation allows 0.04 gr/scf for <150,000 scfm, 0.02 gr/scf for ≧300,000 scfm, with a sliding scale between. These regulations are shown in Figure 8-2.

FUGITIVE DUST

The South Coast Air Basin rule for control of fugitive dust is the most comprehensive currently in use in California. This regulation compares well with regulations in other areas for controlling fugitive dust from industrial and commercial activities. Specifically, the regulation of no visible emissions beyond the property line and an upwind-downwind limit of 100 $\mu g/m^3$ (5 h minimum) are generally as stringent as is found elsewhere.

There are, however, some weak areas in the South Coast rule. This rule does not expand on what is considered a "reasonable precaution." Some states, such as Colorado, have included abatement and preventative measures in their regulations. Other reasonable precautions, not currently in regulations but worth considering, are given in Table 8-4. In addition, the South Coast rule specifically exempts a large part of the total fugitive dust emissions by excluding public, unpaved roads and agriculture. The Colorado regulations address control of both public and private, unpaved roads. Intergovernmental agreements are used to identify and schedule paving of unpaved roads. Agricultural operations are covered by Arizona regulations that require reasonable precautions to prevent particulate matter from becoming airborne. Pima County, Arizona regulations require precautions to limit dust from a vacant lot or dust from an urban or suburban, open area caused by vehicles or animals.

FUEL BURNING/COMBUSTION

Most states have fuel burning emission limitations (lb/10^6 Btu) related to heat input (10^6 Btu/h) rather than regulations limiting hourly emissions (lb/h) as found in some areas of California. These different types of regulations are compared in Figure 8-3. The District of Columbia, Massachusetts, and New Jersey regulations, also shown in this figure, represent the most stringent regulations found elsewhere. As can be seen, the District of Columbia rule is more stringent for steam generators

TABLE 8-4. EXAMPLE REASONABLE PRECAUTIONS FOR PREVENTION AND CONTROL OF FUGITIVE DUST

For land clearing, excavating, grading, earthmoving, dredging, or demolition:

(1) wetting down, including prewatering
(2) stabilizing with chemicals
(3) applying dust palliatives
(4) disturbing less topsoil per unit of time and reclaiming disturbed areas as quickly as possible
(5) restricting the speed of vehicles traversing the area

For constructing, using, altering, or repairing private roads or parking facilities:

(1) watering, paving, or chemically stabilizing routinely used haul roads
(2) restricting the speed of vehicles
(3) watering down or chemically stabilizing roadway shoulders
(4) enclosing or covering open bodied trucks
(5) switching from moving materials by vehicle to moving them by conveyance systems
(6) covering, shielding, or enclosing the area
(7) preventing and/or promptly removing the deposit of dirt and mud on paved roads
(8) cleaning paved roads frequently

For crushing, screening, handling, conveying, or processing materials:

(1) installing hoods, fans, and exhaust systems to enclose and vent the processing of dusty materials
(2) covering conveyance systems
(3) enclosing aggregate storage piles, or reducing the amount of vehicular or aggregate movement on open storage piles
(4) moisturizing or chemically treating the material during processing
(5) sealing leaks or openings in process enclosures

For exposure of land or materials subject to erosion by wind:

(1) landscaping and replanting exposed areas with native vegetation
(2) installing wind screens or equivalent wind speed reduction devices
(3) stabilizing the land with chemicals
(4) physically stabilizing the land by covering with a nonerodible material such as gravel
(5) enclosing aggregate storage piles

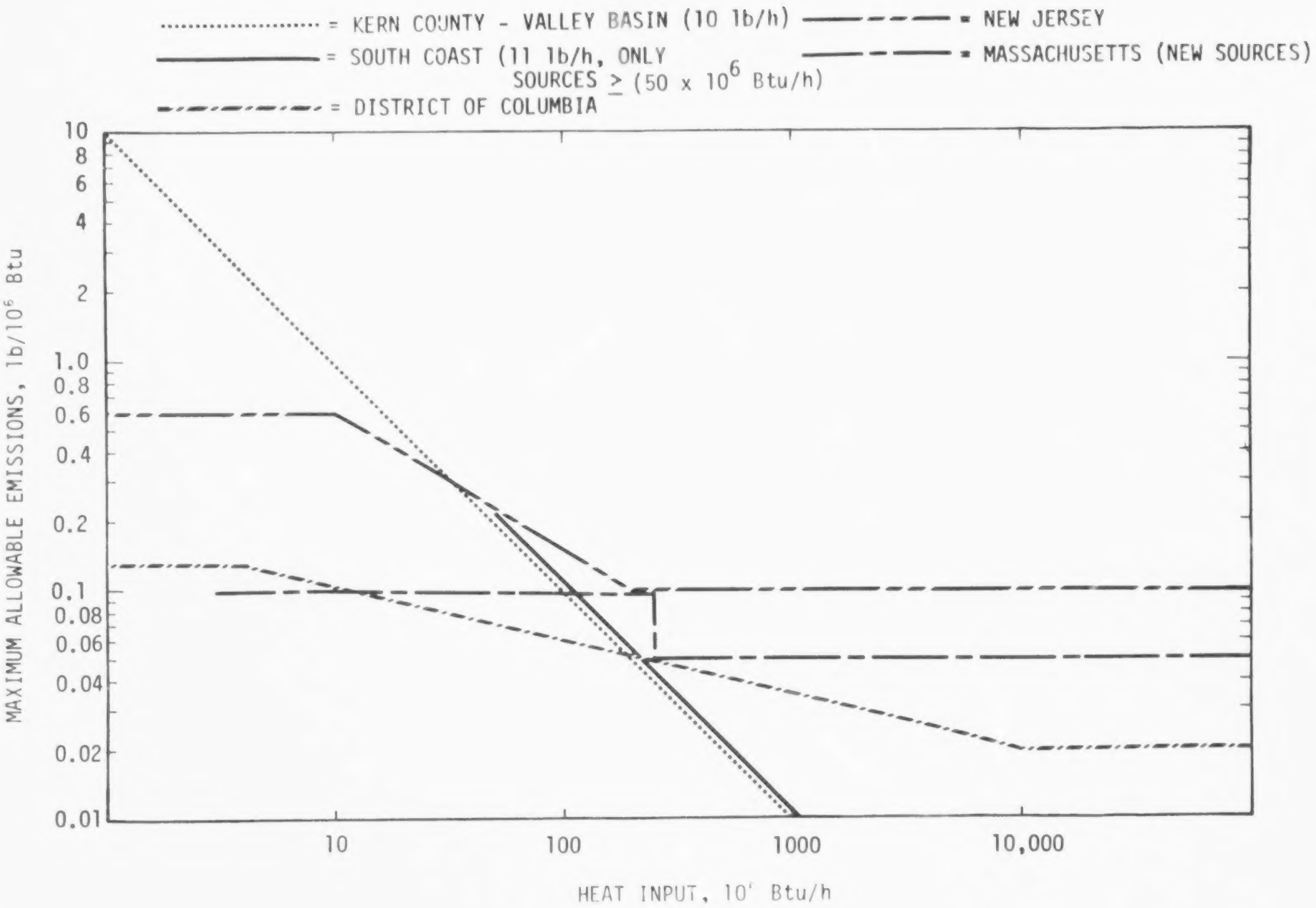

Figure 8-3. Comparison of fuel burning/combustion TSP regulations.

smaller than 150 (10^6) Btu/h, but the South Coast or Kern County (Valley Basin) rule is more stringent for larger generators.

The concentrations of combustion contaminants are also regulated in California. Table 8-5 lists the most stringent limitation found outside the state. In comparison, no concentration regulation was found to be more stringent than that of the South Coast Air Basin for steam generators larger than 50 (10^6) Btu/h. For units smaller than 50 (10^6) Btu/h the combustion concentration regulations in Alaska, Maryland, and Philadelphia, are more stringent.

INCINERATION

Many states have emission limitations based on the quantity of refuse burned (i.e., lb/ton), but these are not readily amenable to comparison with the concentration type of regulation. Only the Metropolitan Baltimore and Washington areas of Maryland are found to have significantly more stringent concentration regulations for incinerators than are found in California. A comparison of these regulations is shown in Figure 8-4. In addition, a listing of the most stringent incinerator concentration regulations for incinerators, found outside California, is presented in Table 8-6. This information shows that, in most cases, the San Diego regulation is most stringent for existing incinerators. Other areas, however, have more stringent regulations for new incinerators.

TABLE 8-5. MOST STRINGENT COMBUSTION CONTAMINATE (TSP) REGULATIONS FOUND OUTSIDE CALIFORNIA

Location	Regulation		
Alaska	0.05 gr/scf (new sources) 0.1 gr/scf (existing sources, and coal or municipal refuse fired)		
Maryland	Distillate oil	No reg.	All sizes
	Residual oil	No reg.	≤13 10^6 Btu/h
	Residual oil	0.03 gr/scf	13-15 10^6 Btu/h
	Residual oil	0.02 gr/scf	50-250 10^6 Btu/h
	Residual oil	0.01 gr/scf	≥250 10^6 Btu/h
	Solid fuel	0.05 gr/scf	≤250 10^6 Btu/h
	Solid fuel	0.03 gr/scf	>250 10^6 Btu/h
Oregon	0.1 gr/scf (new sources) 0.2 gr/scf (existing sources)		
Philadelphia	0.1 lb/1000 lb stack gas (0.05 gr/scf) (new sources) 0.2 lb/1000 lb stack gas (0.1 gr/scf)		

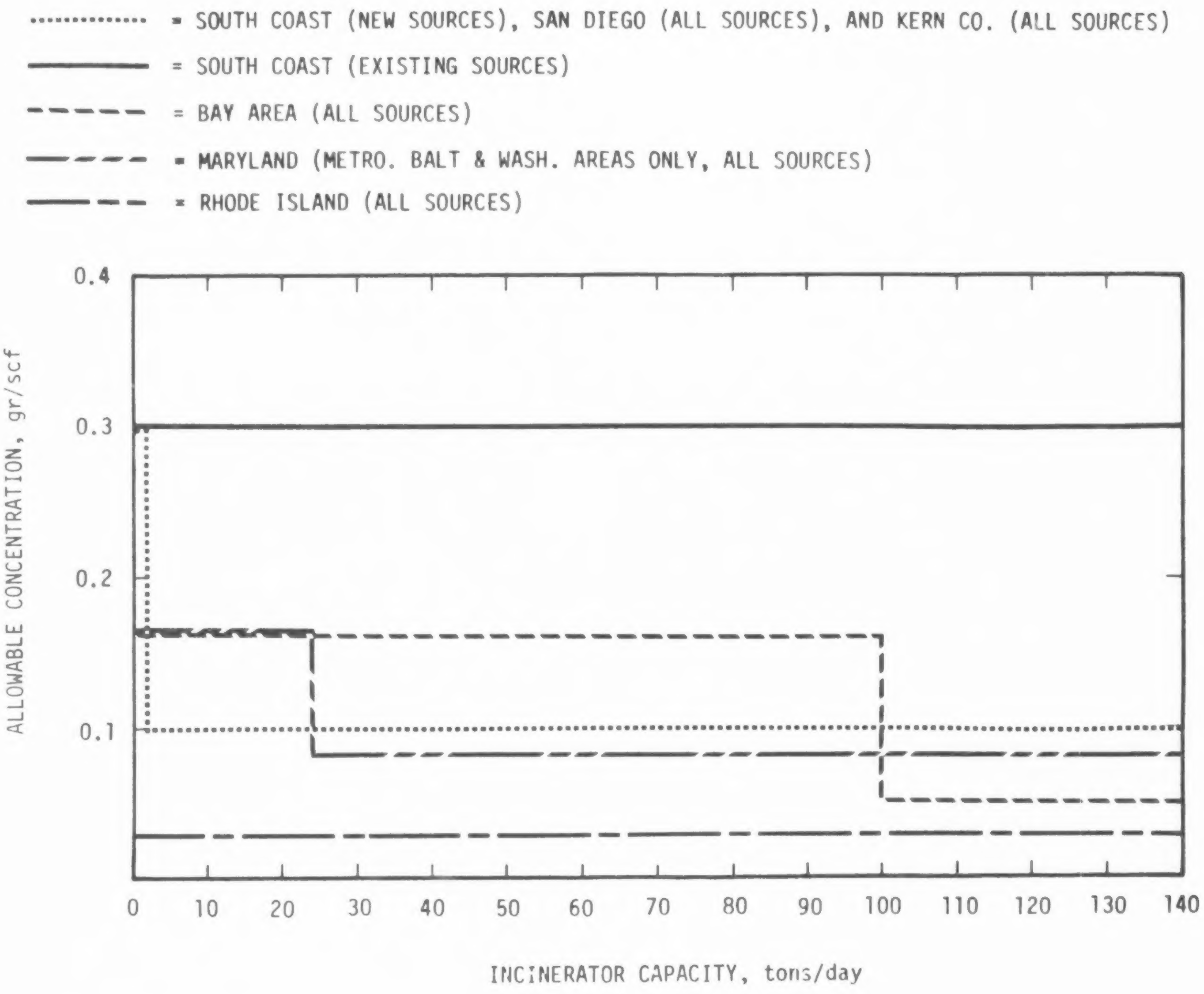

Figure 8-4. Comparison of incineration TSP regulations.

TABLE 8-6. MOST STRINGENT INCINERATOR CONCENTRATION REGULATIONS FOUND OUTSIDE CALIFORNIA

Location	Regulation
Connecticut	0.4 lb/1000 lb flue gas (0.2 gr/scf) - existing, 50% excess air 0.08 gr/scf - new, 12% CO_2
Florida	0.1 gr/scf - existing $\geq$50 tons/day, 50% excess air 0.08 gr/scf - new $\geq$50 tons/day, 50% excess air
Kentucky	0.2 gr/scf - existing and new $\leq$50 tons/day, 12% CO_2 0.08 gr/scf - new >50 tons/day, 12% CO_2
Maryland	
Baltimore and Washington Metropolitan areas	0.03 gr/scf - existing and new
Remainder of state	0.3 gr/scf - existing <200 lb/h 0.2 gr/scf - existing $\geq$200 lb/h 0.1 gr/scf - new <2000 lb/h 0.03 gr/scf - new $\geq$2000 lb/h
Rhode Island	0.16 gr/scf - existing and new, <2000 lb/h, 12% CO_2 0.08 gr/scf - existing and new, $\geq$2000 lb/h, 12% CO_2

SECTION 9

DESIGN FOR ADDITIONAL STUDIES

According to the data presented in Section 7, there are three sources of particulate air pollution that have major impacts upon TSP levels at the sampling sites investigated in this study: natural background and regional sources, secondary aerosols, and local fugitive dust. Some variation in the magnitude of impact from these sources has been noted. Secondary aerosols are much less significant in the Sacramento Valley than in the San Joaquin Valley, and less significant on the western side of the San Joaquin Valley than on the eastern side. Local fugitive dust sources play somewhat greater roles at some sites than they do at others. But, these three sources are generally the only ones that have quantitatively significant effects on TSP. One exception to this statement relates to Fort Bragg. That sampling site clearly has been impacted significantly by sea salt and by emissions from one local point source.

This array of impacting sources poses significant control problems for the California ARB and local air pollution control divisions. As Section 8 indicates, most reasonably available control measures relate to primary particulate emissions from point sources, not secondary aerosols or fugitive dust.

This section will, therefore, focus on suggesting additional studies that could be undertaken to pinpoint specific source subcategories, which dominate the emission profile from the three aforementioned sources, and to document the effect of implementing various alternative control measures for these source subcategories.

NATURAL BACKGROUND AND REGIONAL SOURCES

This source category encompasses a wide variety of specific sources and activities, the most common of which, according to Section 7, are the following:

- Natural background
- Industrial processes and fuel combustion sources that are >5 mi from hi vol sampler sites (e.g., motor vehicle traffic and cotton gins)

- Fugitive dust sources that are >1 mi from sampler sites:
    - railroad yards and rights-of-way
    - paved streets
    - unpaved roads and parking lots
    - cleared areas
    - construction activities
    - aggregate storage piles
    - agricultural activities, tilling, wind erosion, and fertilizer/pesticide application
- Agricultural burning

If a natural background concentration of 35 to 45 μg/m^3 is assumed and if the percents contained in Table 7-4 are accepted as indicative of the contribution from natural background and regional sources, then the percent contribution from natural background at the special study sites can be calculated (see Table 9-1).

The TSP statistics presented in Section 3, the microscopy data presented in Section 4, and the elemental data presented in Section 5, provide clues as to the nature of the predominant regional sources:

- High TSP concentrations tend to occur during periods of light and variable winds, suggesting that the dominant sources may not be far from the sampling sites and that mechanical processes, rather than wind erosion, are the primary cause of initial entrainment of the primary particulates.
- By far the major portion of the particulate matter found under the microscope was attributable to large mineral particles, again suggesting that the dominant sources may not be far from the samplers and are related either to soils or to mineral processing industries.
- Factor analysis indicated that soil-related sources explained most of the variance of TSP.

These factors tend to exclude fuel combustion, agricultural burning, and industrial processes as major components of the regional source subcategory and tend to confirm the dominance of

TABLE 9-1. RELATIVE CONTRIBUTIONS TO NATURAL BACKGROUND AND REGIONAL SOURCES' CATEGORY

Site	Natural background contribution, %	Regional source contribution, %
Bakersfield (Flower)	40-54	46-60
Taft	100	0
Kern Refuge	64-83	17-36
Visalia	63-81	19-37
Parlier	47-90	10-53
Fresno (Cal State)	56-100	0-44
Five Points	65-84	16-35
Merced	81-100	0-19
Modesto (J St)	56-76	24-44
Woodland	64-90	10-36
Live Oak	56-74	26-44
Chico	73-100	0-27
Fort Bragg	52-67	33-48
Paso Robles	100	0

regional fugitive dust sources. According to available ARB emission inventory data, unpaved roads, agricultural operations, and paved roads are easily the largest of such regional fugitive dust sources.

Logical deduction from the aforementioned information suggests that a major focus for study should be on the effect of control of these sources within a defined distance from one of the special study sites used in this report. How to estimate that distance may itself be a crucial question, however.

There are five major variables which affect the rate of depletion for emissions from a given fugitive dust source:

- Atmospheric stability
- Wind speed
- Density of emitted particles
- Mass median diameter (MMD) of emitted particles
- Initial strength of emissions[1]

Figure 9-1 graphically displays the effect of varying stability classes for an assumed settling velocity (which is a function of particle density and MMD) of 5 cm/s and a wind speed of 5 m/s. In order to assess the effect of varying any of the five variables itemized, the following equation can be used:[1]

$$\left(\frac{Q_x}{Q_o}\right)_2 = \left(\frac{Q_x}{Q_o}\right)_1^{.00301\,\alpha_2 D_2^{\,2}/\mu_2}$$

where Q_x/Q_o = ratio of downwind source strength to initial source strength

α = particle density, g/cm^3

D = MMD, μm

μ = wind speed, m/s

A cursory examination of this equation indicates that Q_x/Q_o is most sensitive to variations in the particle MMD. And, as Table 9-2 documents, relatively minor variations in the particle MMD emitted from a source can have major effects on the source's depletion factor.

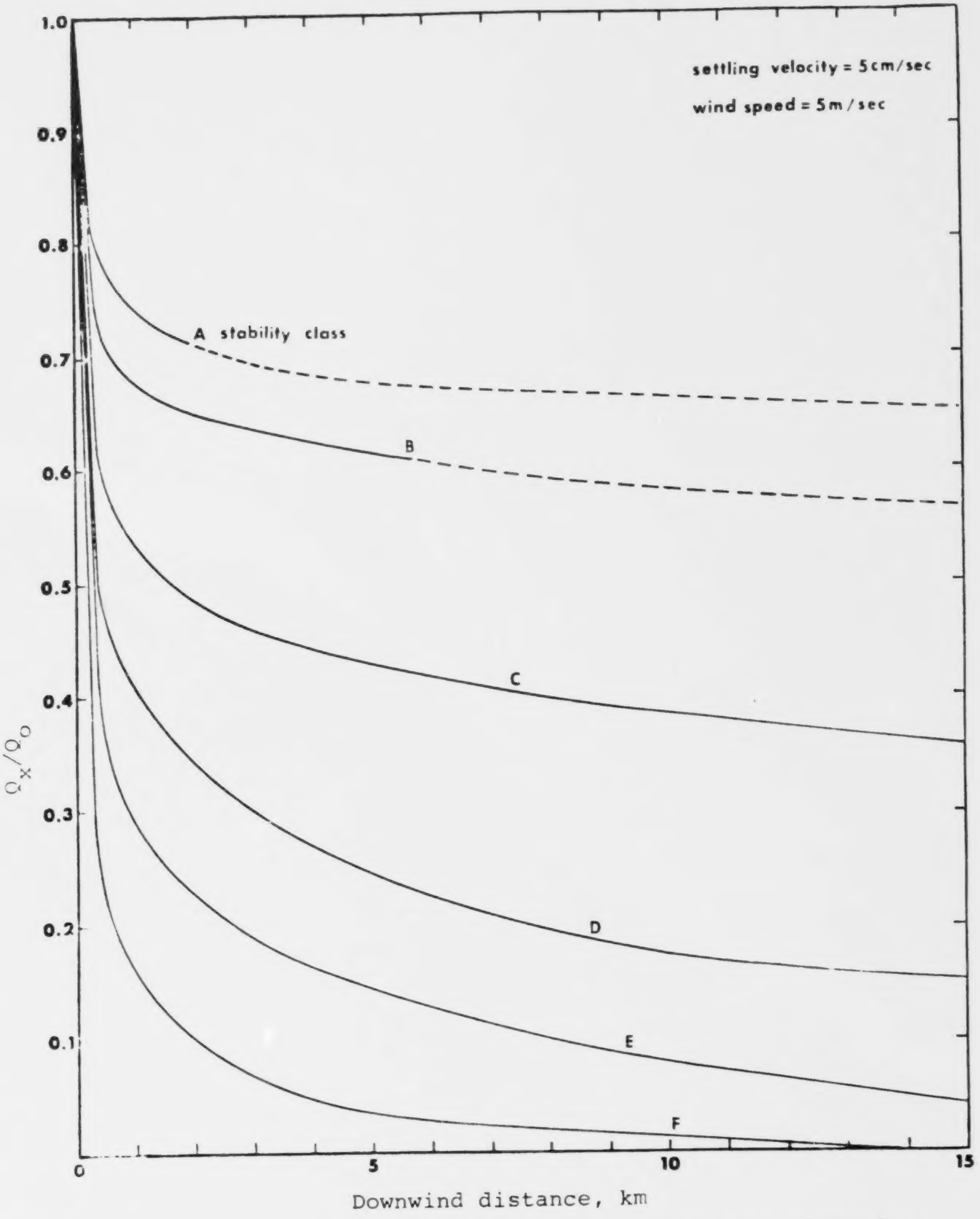

Figure 9-1. Source depletion factors by stability class for ground level sources.

Source: Reference 1

TABLE 9-2. THE EFFECTS OF VARIABLES UPON SOURCE DEPLETION FACTORS

Variable	Midwestern states[a]		Daytime (fall) California		Nighttime (fall) California	
Stability class	B	D	B	B	D	D
Wind speed, m/s	5	5	8	5	6	5
Settling velocity, cm/s	5	5	2	2	2	2
Q_x/Q_o at						
1 km	0.68	0.41	0.91	0.86	0.80	0.70
2 km	0.65	0.34	0.90	0.84	0.76	0.65
3 km	0.64	0.30	0.89	0.84	0.74	0.62
4 km	0.63	0.27	0.89	0.83	0.72	0.59
5 km	0.61	0.24	0.88	0.82	0.70	0.57
10 km	0.58	0.17	0.87	0.80	0.64	0.49
15 km	0.56	0.15	0.87	0.79	0.62	0.47

[a] Reference 1.

From this, it is concluded that a major item of investigation for the ARB should be into MMD's for particles emitted by unpaved roads, paved roads, and agricultural fields within a 10 km radius of one of its hi vol sampler sites. Concurrent measurement of particle density would also be appropriate. From these data, estimates could be made of the impact range of regional sources surrounding a sampler and the effect of controlling emissions from these sources could be tested in one pilot program.

It should be noted that the ARB recently engaged a contractor to perform a project entitled *The Role of Agricultural Practices in Fugitive Dust Emissions*.[2] This certainly represents an important step toward the effective control of what this study has referred to as regional sources.

SECONDARY AEROSOLS

Three types of secondary aerosols were highlighted in the earlier sections of this report: $SO_4^=$, NO_3^-, and organics. A cursory review of Sections 5 and 7 reveals that further work is needed to characterize the secondary aerosol contribution to TSP levels and to define the relative magnitudes of precursor emissions from sources. This subsection suggests some steps that can be undertaken in order to accomplish this objective.

On a world-wide basis, there are six sources of S:

- Industry, space heating, and transportation mainly SO_2, SO_3, and H_2S
- Fertilizers, mainly $SO_4^=$
- Crustal rock, mainly $SO_4^=$
- Biological decay, mainly H_2S
- Sea spray, mainly $SO_4^=$
- Volcanoes, SO_2, H_2S, $SO_4^=$

In addition, large amounts of S-containing pesticides (especially pure S and H_2SO_4) are heavily used in California.[4]

These sources of S generally contribute to the following atmospheric cycle: H_2S oxidize to SO_2 within hours, SO_2 slowly oxidize to SO_3 (but oxidize more quickly in moist air), SO_3 rapidly combine with water to form H_2SO_4 (strongly associated with poor visibility owing to the low dew point of that chemical), and $SO_4^=$ react with other materials in the air to form NH_4SO_4 and $CaSO_4$, which then precipitate out of the air.[3]

Generally correct though this statement may be, it fails to convey the full complexity of $SO_4^=$ formation. As a recent review of the state-of-the-art in airborne $SO_4^=$ measurement reveals,

> ...quantitative information concerning the rates and mechanisms of formation and dispersal of sulfate in the atmosphere are still critically sparse. Even the physical and chemical nature of airborne sulfate (e.g., the size distribution and physical state of sulfate in particles and the cations associated with individual sulfate ions) is largely unknown.[5]

Given this situation, the task confronting the ARB is to define the relative contributions to SO_2 emissions by motor vehicle activity and crude oil steam generators; to define the $SO_4^=$ conversion mechanisms for these sources, and to define the pesticide contributions to secondary $SO_4^=$ levels.

In line with this reasoning, the ARB has recently proposed a rule to control emissions of S compounds from crude oil steam generators used in Kern County.[6]

Secondary NO_3^- present a completely different type of problem than $SO_4^=$ do. The difficulties associated with sampling and analysis of that chemical have rendered virtually all of its measurements highly suspect. It can only be suggested that the ARB pursue efforts that hold promise of yielding scientifically acceptable NO_3^- data.

There is a clear need for a more detailed definition of the role and sources of carbonaceous materials in the central valleys. First, the fraction of TSP contributed by carbonaceous materials must be quantified more precisely. There are too many uncertainties associated with BSO sampling and analysis to depend solely upon the BSO extraction procedure. Further, BSO extracts represent only a certain portion of the total amount of carbonaceous material present on a filter. Second, the sources of carbonaceous material in the atmosphere must be defined. At the present time, it is possible to make nothing more than inferential judgments concerning the probable sources of the carbonaceous material apparent under BSO analyses.

One recent effort, sponsored by the ARB, led to publication of a document entitled Characterization of Organic Particulate Matter.[7] This document reports one of the more recent and better attempts to manage the challenge cited above. Using cyclohexane to extract the primary organic fraction, benzene followed by 2:1 v/v chloroform/methanol to extract the total organic fraction, subtracting the former from the latter to obtain an estimate of the secondary organic fraction, and using mass spectrometric thermal analysis to obtain elemental C (unsoluble) fraction, the authors of this report produced the data summarized in Table 9-3. It would appear from a review of this information that the most likely major sources of carbonaceous material in the nonattainment areas are motor vehicle exhaust, fuel oil combustion (unique to the south San Joaquin Valley), gasoline evaporation, and agricultural burning.

The ARB possesses a unique opportunity to detail the impact of both secondary aerosols and natural background and regional sources. The Kern Refuge site measures concentrations in excess of the primary annual NAAQS for TSP, has been shown to be free of significant impact from highly localized sources, and has shown evidence of relatively high S (hence, probably high secondary aerosol) concentrations. The ARB could install an automated dichotomous sampler, use teflon filters to maximize the retrieval of high quality elemental data, operate continuously for one year, and analyze the resulting loaded filters with XRF. At the same time, the ARB could obtain daily hi vol filter samples and analyze the results for SO_4^-, NO_3^-, and carbonaceous fractions discussed above. Elemental analyses of surrounding soils and steam generator exhaust particulates could be obtained at the same time that particle MMD and density values are being garnered. The resulting data could be analyzed quite efficiently with factor analysis and, if adequate emission data are collected, chemical element balance. This analysis of data from the Kern Refuse site would provide the following important information:

- Source contributions (from factor analysis and chemical element balance)
- Natural background concentration (soil minerals plus unaccounted carbonaceous material)
- Source contributions from secondary aerosols and regional sources to respirable and inhalable particulate concentrations; natural background levels for these two particulate fractions (from the above analyses, using dichotomous sampler data)

LOCAL FUGITIVE DUST

There are two major sources of local fugitive dust identified in Section 6 of this report: unpaved roads and parking lots, and paved streets. It would be a relatively simple task for the ARB to design a special study documenting the effect of implementing a pilot street cleaning and/or a road/parking lot paving program. A sample design for such a field study has been published and is available from either the contractor or EPA's Office of Air Quality Planning and Standards. The report is

TABLE 9-3. CHARACTERIZATION OF ORGANIC PARTICULATE MATTER

Fraction	Approx % of particulate-phase C	Extraction process	Components	Major sources
Primary organics	15	Soluble in cyclohexane (provides upper limit estimate)	Alkanes, alkenes, substituted benzenes, phthalates	Motor vehicle exhaust, combustion of organic material of biological origin, municipal waste incineration
Secondary organics	35	Total organics-primary organics (provides lower limit estimate)	Cyclic olefins, aromatics, terpenes, aliphatic dienes	Auto exhaust, evaporation of unburned gasoline, fuel oil combustion
Total organics	50 (25% benzene, 25% chloroform/methanol)	Benzene followed by 2:1 chloroform/methanol		
Elemental C	50	Insoluble in benzene and chloroform/methanol (total C determined by mass spectrometry)		Tire dust, motor vehicle soot, pollen, fungi, spores, insect parts, carbonates

Source: Reference 7

entitled Field Study Design for the Control of Reentrained Dust in Chattanooga.[8] Other than financial resources, the only major limitation to the feasibility of implementing a pilot street cleaning program is the need for an adequate water supply.

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APPENDIX A

INTERSITE CORRELATIONS

This appendix presents an intersite correlation matrix for each of the five regional groups of sites, as well as one-on-one site correlations between special study sites and their surrounding sites.

CORRELATION MATRIX FOR GROUP 1

	Willits	Fort Bragg	Paso Robles	Corning
Willits	-----			
Fort Bragg	.1688	-----		
Paso Robles	.6088	.1615	-----	
Corning	.2923	.0500	.4042	-----
Average correlation	.3540	.1268	.3888	.2488

CORRELATION MATRIX FOR GROUP 2

	Red Bluff	Red Bluff (Ag Comm)	Red Bluff (Lincoln)	Corning	Los Molinos	Dunnigan	Marysville	Wheatland
Red Bluff	-----							
Red Bluff (Ag Comm)	.7481	-----						
Red Bluff (Lincoln)	.8044	.7889	-----					
Corning	.7845	.8505	.7911	-----				
Los Molinos	.8202	.8633	.8087	.8442	-----			
Dunnigan	.5775	.6532	.6527	.7594	.6766	-----		
Marysville	.5644	.6451	.6610	.6590	.7006	.6930	-----	
Wheatland	.5480	.4942	.5425	.6231	.6373	.7112	.6886	-----
Average correlation	.6927	.7205	.7213	.7588	.7644	.6748	.6591	.6064

CORRELATION MATRIX FOR GROUP 3

	Sacramento (P St)	Sacramento (Branch)	West Sacramento	Dunnigan	Marysville	Wheatland
Sacramento (P St)	-----					
Sacramento (Branch)	.8843	-----				
West Sacramento	.9445	.8665	-----			
Dunnigan	.5864	.5811	.6211	-----		
Marysville	.6018	.6541	.6602	.7494	-----	
Wheatland	.6259	.6106	.6752	.7591	.7643	-----
Average correlation	.7286	.7193	.7535	.6594	.6860	.6870

CORRELATION MATRIX FOR GROUP 4

	Five Points	Fresno (Cal State)	Fresno (Olive)	Merced	Los Banos	Merced (18 and S)	Modesto (J St)	Modesto (Oakdale)
Five Points	-----							
Fresno (Cal State)	.5535	-----						
Fresno (Olive)	.6653	.8413	-----					
Merced	.7302	.7747	.9058	-----				
Los Banos	.6871	.6076	.7914	.8256	-----			
Merced (18 and S)	.5953	.8060	.9104	.9223	.7837	-----		
Modesto (J St)	.5748	.5888	.7383	.7311	.8220	.7496	-----	
Modesto (Oakdale)	.6164	.7576	.8179	.8494	.8240	.8619	.8362	-----
Average correlation	.6318	.7042	.8101	.8199	.7631	.8042	.7201	.7948

CORRELATION MATRIX FOR GROUP 5

	Five Points	Fresno (Cal State)	Fresno (Olive)	Bakersfield (Chester)	Merced	Los Banos	Merced (18 and S)	Visalia	Three Rivers	Goshen
Five Points	-----									
Fresno (Cal State)	.5408	-----								
Fresno (Olive)	.5377	.8742	-----							
Bakersfield (Chester)	.3885	.6008	.6014	-----						
Merced	.5160	.8028	.8534	.5011	-----					
Los Banos	.5686	.6502	.7468	.4478	.7192	-----				
Merced (18 and S)	.5076	.8343	.8828	.5434	.9046	.7480	-----			
Visalia	.5077	.7007	.7591	.6739	.6599	.5102	.6498	-----		
Three Rivers	.6046	.4505	.4382	.3795	.3677	.3218	.4029	.5202	-----	
Goshen	.6502	.6899	.7563	.6261	.7055	.6627	.6347	.7865	.6744	-----
Average correlation	.5457	.6827	.7167	.5292	.6700	.5973	.6787	.6409	.4622	.6874

ONE-ON-ONE SITE CORRELATIONS

Site	Correlated site	No. of samples	Sample r	95% confidence limit descriptor
Chico	Corning	151	.772	Very good
	Los Molinos	142	.759	Very good
	West Sacramento	148	.774	Very good
	Marysville	141	.732	Very good
	Red Bluff	143	.695	Very good
	Red Bluff (Ag Comm)	150	.684	Very good
	Red Bluff (Lincoln)	123	.811	Very good
	Nord	102	.633	Good
	Sutter City	124	.664	Good
	Yuba City	4	.716	Insufficient data
	Wheatland	139	.698	Very good
Live Oak	West Sacramento	122	.639	Good
	Corning	119	.668	Good
	Marysville	106	.744	Very good
	Chico	112	.682	Good
	Nord	89	.547	Fair
	Sutter City	114	.734	Very good
	Yuba City	5	.880	Insufficient data
	Wheatland	114	.680	Good
	Dunnigan	121	.694	Good
	Pleasant Grove	98	.549	Fair
	Woodland	108	.736	Very good
	Sacramento (Branch)	118	.591	Good
	Rancho Cordova	61	.687	Good
	Sacramento (P St)	113	.643	Good
	Los Molinos	114	.530	Fair
Willits	Capella	140	.723	Very good
West Sacramento	Los Banos	165	.753	Very good
	Modesto (J St)	171	.669	Good
Woodland	Sutter City	116	.743	Very good
	Marysville	140	.719	Very good
	Wheatland	144	.737	Very good
	Dunnigan	159	.824	Very good
	Pleasant Grove	106	.697	Good
	West Sacramento	155	.844	Very good
	Sacramento (P St)	148	.828	Very good
	Sacramento (Branch)	154	.775	Very good
	Rancho Cordova	98	.669	Good
	Vacaville	111	.846	Very good
	Rio Vista	133	.779	Very good
Modesto (J St)	Stockton	108	.098	Very poor
	Salida	116	.699	Good
	Patterson	118	.677	Good
	Turlock	140	.765	Very good
Merced	Salida	105	.736	Very good
	Patterson	111	.584	Good
	Turlock	134	.858	Excellent
	Madera	36	.450	Poor
Fresno (Cal State)	Coalinga	75	.616	Good
	Madera	4	.993	Insufficient data
	Hanford	34	.114	Poor
	Lemoore	44	.313	Very poor
	Stratford	57	.364	Poor
	Corcoran	29	.720	Insufficient data
	Kettleman City	51	.514	Fair

(continued)

TABLE (continued)

Site	Correlated site	No. of samples	Sample r	95% confidence limit descriptor
Parlier	Fresno (Cal State)	98	.670	Good
	Fresno (Olive)	124	.647	Good
	Goshen	125	.797	Very good
	Visalia	121	.766	Very good
	Five Points	98	.612	Good
	Madera	17	.688	Insufficient data
	Three Rivers	125	.630	Good
	Hanford	43	.587	Fair
	Lemoore	53	.356	Poor
	Stratford	67	.273	Poor
	Corcoran	35	.757	Good
	Kettleman City	56	.620	Good
	Porterville	80	.705	Good
	Porterville (S. Main)	45	.828	Very good
Kettleman City	Hanford	28	.578	Insufficient data
	Lemoore	43	.644	Good
	Stratford	47	.693	Good
	Corcoran	32	.830	Very good
	Five Points	53	.544	Fair
	Coalinga	41	.496	Fair
	Visalia	61	.622	Good
	Goshen	64	.567	Fair
	Porterville	35	.572	Fair
	Porterville (S. Main)	29	.516	Insufficient data
	Fresno (Olive)	62	.614	Good
Kern Refuge	Hanford	43	.674	Good
	Lemoore	30	.695	Good
	Stratford	46	.673	Good
	Corcoran	25	.684	Insufficient data
	Kettleman City	38	.643	Fair
	Visalia	96	.728	Very good
	Porterville	75	.526	Fair
	Porterville (S. Main)	21	.891	Insufficient data
	Bakersfield (Flower)	99	.593	Good
Taft	Kern Refuge	60	.615	Good
	Five Points	60	.399	Poor
	Goshen	82	.573	Good
	Bakersfield (Flower)	81	.694	Good
	Paso Robles	83	.643	Good
Bakersfield (Chester)	Bakersfield (Flower)	133	.893	Excellent
	Taft	80	.693	Good
	Kern Refuge	103	.621	Good
	Coalinga	77	.382	Poor
	Porterville	112	.573	Good
	Porterville (S. Main)	46	.810	Very good
	Bakersfield (Fruitvale)	48	.807	Very good
	Bakersfield (Foothill)	42	.783	Very good
	Bakersfield (Greenfield)	30	.724	Good
	Bakersfield (Armory)	38	.904	Excellent
	Bakersfield (Kern City)	35	.906	Excellent
	Bakersfield (Mt.Vernon)	36	.812	Very good

APPENDIX B

MICROSCOPIC ANALYSES

This appendix presents Denver Research Institute's data reduction report for materials examined from each of 55 filters furnished by ARB. Six filters were analyzed for each of the eight Phase I sites and the Merced site. Data for one additional filter, from Visalia, is also presented.

Results in the following section are presented in terms of grams of material or numbers of particles per square centimeter (cm^{-2}) of Nuclepore filter. An estimate of the amount of material of any type deposited upon the glass fiber filter may be made by dividing observed concentrations ($gm\ cm^{-2}$) by 7.95×10^{-5}, which is derived from the dilution series used to prepare suitable SEM substrates.

Footnotes, explanation:

[1] Figures, if present, are probably not representative because of the small number of particulates sampled.

[2] Excessive material present, size distributions of particle size usually not possible; mass estimate procedure described for each case.

3339
3/8/77

Particulate Analyses Form - DRI

Sample Identification Bakersfield - 25

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Flyash ~~Other~~
> 20μm	-	-			
10μm - 20μm	1.92×10^4	-			
10μm - 5μm	2.40×10^4	9.63×10^3			
5μm - 2μm	1.78×10^5	1.92×10^5			$(9.01 \times 10^{-4})^1$
2μm - 1μm	4.51×10^5	6.58×10^6	$(9.01 \times 10^{-4})^1$		
1μm - 0.5μm	1.80×10^5	6.58×10^6			
0.5μm - 0.2μm	-	6.58×10^6			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	XXXXXX
> 2.0μm	2.21×10^{-5}	7.15×10^{-6}			$(4.15 \times 10^{-6})^1$
< 2.0μm	2.50×10^{-6}	4.48×10^{-7}	9.82×10^{-7}		

Comments: Mineral types varied but usually Si Rich (a few S,Cu Rich).

3214
12/20/76

Particulate Analyses Form - DRI

Sample Identification Bakersfield (26)

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$) Mineral	Carbonaceous	Metal	Salt	Flyash XXXXX
> 20μm	7.60×10^{3}	-			
10μm - 20μm	1.52×10^{4}	7.60×10^{3}			
10μm - 5μm	7.60×10^{4}	3.05×10^{4}			$(7.61 \times 10^{3})^{1}$
5μm - 2μm	2.05×10^{5}	4.81×10^{5}			
2μm - 1μm	1.53×10^{6}	1.35×10^{6}			
1μm - 0.5μm	2.70×10^{5}	3.97×10^{7}			
0.5μm - 0.2μm	-	3.97×10^{7}			

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$) Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	5.81×10^{-5}	1.28×10^{-5}			$(5.30 \times 10^{-6})^{1}$
< 2.0μm	7.29×10^{-6}	3.71×10^{-6}			

Comments: Ca S types slightly more predominate. Very packed filter.
Agglomerates of small particulates of carbon (ie. soot) evident.
Rather high carbon particulate to mineral particulate ratio.

3211
12/2/76

Particulate Analyses Form - DRI

Sample Identification Bakersfield 27

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	$4.81x10^3$	-			
10μm - 20μm	$1.92x10^4$	$9.61x10^3$			
10μm - 5μm	$6.73x10^4$	$1.92x10^4$			
5μm - 2μm	$1.83x10^5$	$1.44x10^5$			
2μm - 1μm	$8.10x10^5$	$3.08x10^7$			
1μm - 0.5μm	$5.40x10^5$	$3.08x10^7$			
0.5μm - 0.2μm	$9.00x10^4$	$3.08x10^7$			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	$5.83x10^{-5}$	$1.22x10^{-5}$			
< 2.0μm	$3.55x10^{-6}$	$1.84x10^{-6}$			

Comments: Similar to 26 - Ca S particulates, not very prevalent.

3009
3/2/76

Particulate Analyses Form - DRI

Sample Identification Bakersfield 28

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	-	-			
10μm - 5μm	9.63 x10^3	-			
5μm - 2μm	2.89 x10^4	5.29 x 10^4			
2μm - 1μm	3.61 x 10^5	9.00 x 10^4			
1μm - 0.5μm	9.02 x 10^4	2.70 x 10^5			
0.5μm - 0.2μm	-	1.89 x 10^6			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	4.29 x 10^{-6}	1.18 x 10^{-6}			
< 2.0μm	1.41 x 10^{-6}	1.38 x 10^{-7}			

Comments: Moderate loading - carbon often "flakelike". Small carbon particulates and agglomerates rare.

9802
5/1/77

Particulate Analyses Form - DRI

Sample Identification Bakersfield 29

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	4.81×10^{3}	-			
10μm - 5μm	1.92×10^{4}	7.21×10^{3}			
5μm - 2μm	3.85×10^{4}	5.41×10^{4}			
2μm - 1μm	5.41×10^{5}	4.42×10^{6}	(4.25×10^{3})		
1μm - 0.5μm	1.80×10^{5}	4.42×10^{6}			
0.5μm - 0.2μm	-	4.42×10^{6}			

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	1.19×10^{-5}	1.58×10^{-6}	(4.25×10^{-8})		
< 2.0μm	2.38×10^{-6}	3.64×10^{-7}	(3.50×10^{-6})		

Comments: Similar to 28, but more mineral particulates

109233
10/10/77

Particulate Analyses Form - DRI

Sample Identification Bakersfield 30

Concentration Analysis:

	Particulate Type ($n\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	3.37×10^4	-			
10μm - 5μm	3.37×10^4	9.66×10^3			
5μm - 2μm	3.37×10^4	1.01×10^5			
2μm - 1μm	3.61×10^5				
1μm - 0.5μm	1.80×10^5				
0.5μm - 0.2μm	-				

Mass Analyses:

	Particulate Type ($gm\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	7.48×10^{-5}	4.05×10^{-6}			
< 2.0μm	1.56×10^{-6}	6.31×10^{-7}			

Comments: High concentration of large mineral particulate, some carbon "flakes". Minerals, large, clays and feldspars. Few agglomerates of (and including) very small $\bar{<}$ μm particulates.

6/23/76
38672

Particulate Analyses Form - DRI

Sample Identification (Parlier)

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	-	-			
10μm - 5μm	6.74×10^4	4.71×10^4			
5μm - 2μm	1.89×10^5	4.00×10^5			
2μm - 1μm	2.47×10^6	1.80×10^5			
1μm - 0.5μm	5.70×10^5	1.98×10^6			
0.5μm - 0.2μm	5.70×10^5	9.00×10^5			

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	2.61×10^{-5}	1.38×10^{-5}			
< 2.0μm	6.64×10^{-6}	1.07×10^{-6}			

Comments: A larger than usual percentage of the particles are rich in CaS (i.e. gypsum). Few very fine particles (0.5-0.2μm).

3/1/76
38558

Particulate Analyses Form - DRI

Sample Identification Kearney 43 (Parlier)

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20µm	--	--			
10µm - 20µm	4.81×10^3	--			
10µm - 5µm	1.90×10^4	4.81×10^3			
5µm - 2µm	1.44×10^4	5.77×10^4			
2µm - 1µm	1.80×10^5	2.70×10^5			
1µm - 0.5µm	4.51×10^5	7.20×10^5			
0.5µm - 0.2µm	--	1.98×10^6			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0µm	1.50×10^{-5}	2.49×10^{-6}			
< 2.0µm	1.06×10^{-6}	5.22×10^{-7}			

Comments:

11/15/77
8340

Particulate Analyses Form - DRI

Sample Identification Kearney 44 (Parlier)

Concentration Analysis:

	Particulate Type ($n\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	--	--			
10μm - 20μm	--	--			
10μm - 5μm	2.88×10^{4}	4.81×10^{3}			
5μm - 2μm	3.37×10^{4}	6.25×10^{4}			
2μm - 1μm	2.71×10^{4}	--			
1μm - 0.5μm	9.02×10^{3}	4.50×10^{5}			
0.5μm - 0.2μm	9.02×10^{3}	2.16×10^{6}			

Mass Analyses:

	Particulate Type ($gm\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	1.04×10^{-5}	2.33×10^{-6}			
< 2.0μm	1.23×10^{-6}	2.38×10^{-7}			

Comments: Lightly loaded samples, especially smaller particles.

11/21/77
8337

Particulate Analyses Form - DRI

Sample Identification Kearney 45 (Parlier)

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	--	--			
10μm - 20μm	--	--			
10μm - 5μm	2.98x10^{4}	--			
5μm - 2μm	3.85x10^{4}	1.63x10^{5}			
2μm - 1μm	6.31x10^{5}	1.80x10^{5}			
1μm - 0.5μm	9.01x10^{4}	1.26x10^{6}			
0.5μm - 0.2μm	9.01x10^{4}	3.34x10^{6}			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	8.15x10^{-6}	3.85x10^{-6}			
< 2.0μm	2.54x10^{-6}	4.76x10^{-7}			

Comments:

1/31/76
40297

Particulate Analyses Form - DRI

Sample Identification Kearney 46 (Parlier)

Concentration Analysis:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type ($n\ cm^{-2}$)				
> 20μm	--	--			
10μm - 20μm	--	--			
10μm - 5μm	2.28×10^4	--			
5μm - 2μm	1.29×10^5	3.65×10^5			
2μm - 1μm	1.68×10^6	3.61×10^5			
1μm - 0.5μm	1.68×10^6	1.68×10^6			
0.5μm - 0.2μm	2.40×10^5	9.86×10^6			

Mass Analyses:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type ($gm\ cm^{-2}$)				
> 2.0μm	7.88×10^{-6}	5.61×10^{-6}			
< 2.0μm	5.86×10^{-6}	8.34×10^{-7}			

Comments: Mineral particulates about 2μm present in high concentration--usually Si or Si with Na. Small carbon "flakes" present as well as agglomerates of smaller particulates. Individual fine particles of lead and CuZn observed. Smaller size fraction of minerals (> 2.0μm) dominates minerals <2.0 μm.

6/18/77
1441

Particulate Analyses Form - DRI

Sample Identification Kearney 54 (Parlier)

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	--	--			
10μm - 20μm	--	--			
10μm - 5μm	1.44×10^4	1.44×10^4			
5μm - 2μm	2.89×10^4	5.77×10^4			
2μm - 1μm	--	4.81×10^5			
1μm - 0.5μm	--	1.08×10^6			
0.5μm - 0.2μm	--	7.21×10^6			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	3.65×10^{-6}	2.84×10^{-6}			
< 2.0μm	--	8.27×10^{-7}			

Comments: Two larger carbon particles organic. One particle of CuZn(Ni) observed. d = 2.5 μm. Also two particles rich in S, d = 0.6 + 0.8 μm. Fairly high concentration of carbon particles between 0.4 and 0.2 μm. Two particles of S and Na, d = 0.8 and 1.9 μm.

1088374
1/1/77

Particulate Analyses Form - DRI

Sample Identification Fresno 37 (Cal State)

Concentration Analysis:

	Particulate Type ($n\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-	-	-	
10μm - 20μm	-	-	-	-	
10μm - 5μm	6.25×10^4	1.44×10^4	-	3.31×10^5	
5μm - 2μm	3.85×10^4	1.78×10^5	-	1.66×10^5	
2μm - 1μm	4.51×10^5	$\left[\ \right]^2$	9.00×10^4	3.61×10^5	
1μm - 0.5μm	4.51×10^5		3.60×10^5	1.80×10^5	
0.5μm - 0.2μm	-		7.2×10^5	-	

Mass Analyses:

	Particulate Type ($gm\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	1.49×10^{-5}	6.91×10^{-6}	-	2.51×10^{-6}	
< 2.0μm	1.39×10^{-6}	$(1.50 \times 10^{-5})^2$	1.02×10^{-6}	1.15×10^{-6}	

Comments: Metals particulate observable in large #s are Pb. This is very obvious. Suggests automotive source.

[2] Agglomerates of small particulates obscure much of Bkgd. Assured that carbon material covered 1/4 of field and was 0.3μm thick. Numerous carbon particles 0.2μm → 2.00μm.

1100074
5/1/77

Particulate Analyses Form - DPI

Sample Identification Fresno 38 (Cal State)

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	S-Rich ~~Other~~
> 20μm	-	-			-
10μm - 20μm	-	-			-
10μm - 5μm	4.81×10^3	-			-
5μm - 2μm	3.37×10^4	5.77×10^4			-
2μm - 1μm	2.71×10^5	1.80×10^5			-
1μm - 0.5μm	2.71×10^5	9.02×10^5			1.80×10^5
0.5μm - 0.2μm	-	2.89×10^6			-

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	S-Rich ~~Other~~
> 2.0μm	2.01×10^{-6}	1.96×10^{-6}			
< 2.0μm	9.36×10^{-7}	4.68×10^{-7}			5.18×10^{-8}

Comments: Highly loaded

38718
8/22/76

Particulate Analyses Form - DRI

Sample Identification Fresno 39 (Cal State)

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	-	-			
10μm - 5μm	1.92×10^4	9.63×10^3	$(9.61 \times 10^3)^1$		
5μm - 2μm	3.37×10^4	2.89×10^4			
2μm - 1μm	3.61×10^5	9.00×10^4			
1μm - 0.5μm	1.80×10^5	4.50×10^5			
0.5μm - 0.2μm	-	2.79×10^6			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	6.17×10^{-6}	2.29×10^{-6}	$(1.24 \times 10^{-5})^1$		
< 2.0μm	1.74×10^{-6}	1.89×10^{-7}			

Comments:

[1] Two large Cu,Zn particulates observed in 1000x fields - probably not representative.

12/20/76
8372

Particulate Analyses Form - DRI

Sample Identification Fresno 40 (Cal State)

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 20µm	-	-	-		
10µm - 20µm	4.81×10^3	-	-		
10µm - 5µm	3.85×10^4	4.81×10^3	9.60×10^3		
5µm - 2µm	1.44×10^4	1.60×10^6 [2]	1.92×10^4		
2µm - 1µm	4.50×10^5		2.70×10^5		
1µm - 0.5µm	5.40×10^5		6.30×10^5		
0.5µm - 0.2µm	7.20×10^5		7.20×10^5		

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0µm	2.37×10^{-5}	3.02×10^{-6}	9.25×10^{-6}		
< 2.0µm	1.37×10^{-6}	(1.00×10^{-5})[2]	2.44×10^{-6}		

Comments: Very high lead particulate concentration- seems to be representative- suggests source for Pb and C seen on this sample and #37-i.e., automotive. Metal all Pb (except one Fe particle).

[2] Estimated using 1/8 total coverage and assuming an average thickness of 0.4µm (there appear to be more larger carbon particles than on sample 37).

38664
6/29/76

Particulate Analyses Form - DRI

Sample Identification Fresno 41 (Cal State)

Concentration Analysis:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (n cm^{-2})				
> 20μm	-	-			
10μm - 20μm	9.64×10^3	-			
10μm - 5μm	3.37×10^4	3.37×10^4			
5μm - 2μm	1.16×10^5	2.21×10^5			
2μm - 1μm	7.20×10^5	1.80×10^5			
1μm - 0.5μm	7.20×10^5	8.11×10^5			
0.5μm - 0.2μm	5.40×10^5	5.68×10^6			

Mass Analyses:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (gm cm^{-2})				
> 2.0μm	2.39×10^{-5}	9.12×10^{-6}			
< 2.0μm	2.14×10^{-6}	4.36×10^{-7}			

Comments: High concentration of large mineral particles but carbon fairly low (smaller fraction).

7/11/76
38728

Particulate Analyses Form - DRI

Sample Identification Fresno #53 (Cal State)

Concentration Analysis:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (n cm^{-2})				
> 20µm	0	0			
10µm - 20µm	0	0			
10µm - 5µm	4.81×10^3	0			
5µm - 2µm	7.21×10^4	1.01×10^5			
2µm - 1µm	6.31×10^5	2.71×10^5			
1µm - 0.5µm	1.80×10^5	8.12×10^5			
0.5µm - 0.2µm	0	3.43×10^6			

Mass Analyses:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (gm cm^{-2})				
> 2.0µm	4.08×10^{-6}	2.96×10^{-6}			
< 2.0µm	3.48×10^{-6}	3.62×10^{-7}			

Comments:

11701

10/27/76

Particulate Analyses Form - DRI

Sample Identification Merced - 013

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$) Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	7.60×10^3	-			
10μm - 5μm	6.08×10^4	6.09×10^4			
5μm - 2μm	4.56×10^4	4.64×10^5			
2μm - 1μm	6.31×10^5	9.02×10^5			
1μm - 0.5μm	1.80×10^5	3.07×10^6			
0.5μm - 0.2μm	-	4.85×10^7			

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$) Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	3.22×10^{-5}	1.62×10^{-5}			
< 2.0μm	3.81×10^{-6}	1.30×10^{-6}			

Comments: Carbon very abundant - similar in morphology to minerals - smaller sizes very numerous but somewhat dissimilar from carbon black (not real tiny) may be from a unique source. Minerals usually Si rich but some "C S" types showing up.

10134

6/23/76

Particulate Analyses Form - DRI

Sample Identification Merced - 014

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$) Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	1.92×10^4	-			
10μm - 5μm	1.92×10^4	-		$(3.60 \times 10^3)^1$	
5μm - 2μm	2.88×10^4	1.39×10^5	$(9.01 \times 10^4)^1$		$(1.80 \times 10^5)^1$
2μm - 1μm	5.41×10^5	1.80×10^5	$(4.81 \times 10^3)^1$		
1μm - 0.5μm	1.80×10^5	2.08×10^6			
0.5μm - 0.2μm	-	8.84×10^6			

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$) Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	2.86×10^{-5}	2.43×10^{-6}	$(1.61 \times 10^{-5}$		$(2.61 \times 10^{-6})^1$
< 2.0μm	2.28×10^{-6}	7.34×10^{-7}	$(1.05 \times 10^{-7})^1$		

Comments: Numerous large Si rich minerals, much less carbon than 013. Metal particulates contained Fe or Cu,Zn. Salts contain predominantly Cu and P.

11839

11/26/76

Particulate Analyses Form - DRI

Sample Identification Merced 15

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 20µm	-				
10µm - 20µm	9.60×10^3				
10µm - 5µm	4.80×10^3	1.44×10^4			
5µm - 2µm	1.44×10^4	7.21×10^4		$(4.81 \times 10^3)^1$	
2µm - 1µm	2.70×10^5	8.09×10^5	$(9.01 \times 10^4)^1$	$(9.01 \times 10^4)^1$	$(9.01 \times 10^4)^1$
1µm - 0.5µm	4.51×10^5	1.80×10^6			
0.5µm - 0.2µm	-	1.34×10^7			

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Flyash
> 2.0µm	6.38×10^{-6}	3.79×10^{-6}	$(1.15 \times 10^{-5})^1$		$(5.37 \times 10^{-8})^1$
< 2.0µm	1.12×10^{-6}	7.75×10^{-7}	-	-	(2.65×10^{-8})

Comments: Three distinct groups of carbonaceous material observed a) large particulates (>0.5 µm) similar in morphology to minerals. b) carbon "flakes" < 0.5 µm and c) very tiny spheres (sometimes in agglomerates) $\bar{<}$ 0.5µm. " C S" particulates occurring with higher frequency. Salt mostly S,K, and SNa metal particulate rich in Cu,ZN,Nu and Ni.

11861

4/13/77

Particulate Analyses Form - DRI

Sample Identification Merced 16

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Sulfur Rich ~~Salt~~	Flyash ~~Other~~
> 20µm	-	-			
10µm - 20µm	2.88×10^4	4.80×10^3			
10µm - 5µm	3.36×10^4	2.88×10^4			
5µm - 2µm	3.36×10^4	2.06×10^5			$(4.81 \times 10^3)^1$
2µm - 1µm	4.51×10^5	4.50×10^5		$(9.01 \times 10^4)^1$	
1µm - 0.5µm	9.02×10^4	1.08×10^6			
0.5µm - 0.2µm	-	8.11×10^6			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0µm	7.86×10^{-5}	1.14×10^{-5}		$(1.63 \times 10^{-7})^1$	$(8.18 \times 10^{-7})^1$
< 2.0µm	1.95×10^{-6}	6.04×10^{-7}			

Comments: Numerous large (Si rich)minerals. Also a number of large Carbon particulates.

11864
5/11/77

Particulate Analyses Form - DRI

Sample Identification Merced 17

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Flyash ~~Other~~
> 20μm	-	-			
10μm - 20μm	-	-			
10μm - 5μm	-	4.81×10^3			$(4.81 \times 10^3)^1$
5μm - 2μm	9.61×10^3	9.31×10^4	$(9.01 \times 10^4)^1$		
2μm - 1μm	4.51×10^5	9.00×10^4			
1μm - 0.5μm	-	5.40×10^5			
0.5μm - 0.2μm	-	2.07×10^6			

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Flyash ~~Other~~
> 2.0μm	1.00×10^{-6}	2.27×10^{-6}	$(9.59 \times 10^{-6})^1$		(3.35×10^{-6})
< 2.0μm	1.87×10^{-6}	1.15×10^{-7}			

Comments: Very clear smaple. Some of the larger carbon is probably organic. G.S quite common. Metal again is Cu,Zn,Na rich

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[1] Based upon a very low sample size.

4377
2/6/76

Particulate Analyses Form - DRI

Sample Identification Merced 18

Concentration Analysis:

	Particulate Type ($n\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	-	-			
10μm - 5μm	-	4.81×10^3			
5μm - 2μm	1.92×10^4	7.21×10^4			
2μm - 1μm	6.30×10^5	3.61×10^5			
1μm - 0.5μm	4.50×10^5	9.92×10^5			
0.5μm - 0.2μm	-	4.78×10^6			

Mass Analyses:

	Particulate Type ($gm\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	4.73×10^{-7}	2.65×10^{-6}			
< 2.0μm	3.02×10^{-6}	3.67×10^{-7}			

Comments: Very clean. Carbon not predominantly biological.

4563
1/25/76

Particulate Analyses Form - DRI

Sample Identification Modesto - 031

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$) Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	1.79×10^{4}	5.93×10^{3}			
10μm - 5μm	2.98×10^{4}	1.19×10^{4}			
5μm - 2μm	7.74×10^{4}	1.48×10^{5}		$(5.93\times10^{3})^{1}$	
2μm - 1μm	1.80×10^{5}	9.01×10^{4}		$(9.01\times10^{4})^{1}$	
1μm - 0.5μm	-	8.11×10^{5}			
0.5μm - 0.2μm	-	5.41×10^{6}			

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$) Mineral	Carbonaceous	Metal	S rich ~~Salt~~	Other
> 2.0μm	3.64×10^{-5}	6.37×10^{-6}		(2.66×10^{-7})	
< 2.0μm	6.04×10^{-7}	2.83×10^{-7}			

Comments: Some larger carbonaceous particulates probably organic. Some C,S minerals evident.

345245
12/3/77

Particulate Analyses Form - DRI

Sample Identification Modesto 32

Concentration Analysis:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (n cm^{-2})				
> 20μm	-	-			
10μm - 20μm	4.80×10^3	-			
10μm - 5μm	1.92×10^4	1.44×10^4			
5μm - 2μm	4.80×10^3	7.21×10^4			
2μm - 1μm	4.51×10^5	2.70×10^5			
1μm - 0.5μm	2.70×10^5	9.01×10^5			
0.5μm - 0.2μm	-	8.65×10^6			

Mass Analyses:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (gm cm^{-2})				
> 2.0μm	1.52×10^{-5}	2.95×10^{-6}			
< 2.0μm	1.95×10^{-6}	3.14×10^{-7}			

Comments: ~~Some larger organic particulates~~, probably biological.

345252
1/14/78

Particulate Analyses Form - DRI

Sample Identification Modesto 33

Concentration Analysis:

Size Range	Particulate Type (n cm^{-2})				
	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	-	-			
10μm - 5μm	9.60×10^3	4.80×10^3			
5μm - 2μm	1.92×10^4	1.15×10^5			
2μm - 1μm	9.00×10^5	9.02×10^4			
1μm - 0.5μm	1.80×10^5	4.78×10^6			
0.5μm - 0.2μm	-				

Mass Analyses:

Size Range	Particulate Type (gm cm^{-2})				
	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	3.58×10^{-6}	3.23×10^{-6}			
< 2.0μm	3.46×10^{-6}	2.75×10^{-7}			

Comments: Moderately clean - One very large particle (>50μm) observed, during overview, to be rich in Cu,Si,Ni.

13186
5/13/77

Particulate Analyses Form - DRI

Sample Identification Modesto 34

Concentration Analysis:

Size Range	Particulate Type (n cm^{-2}) Mineral	Carbonaceous	Metal	Salt	Other
> 20µm	-	-			
10µm - 20µm	4.80 x 10^3	-			
10µm - 5µm	-	-			
5µm - 2µm	1.44 x 10^4	1.01x 10^5			
2µm - 1µm	2.48 x 10^5	2.67 x 10^5			
1µm - 0.5µm	8.25 x 10^4	8.00 x 10^5			
0.5µm - 0.2µm	-	2.13 x 10^6			

Mass Analyses:

Size Range	Particulate Type (gm cm^{-2}) Mineral	Carbonaceous	Metal	Salt	S - Rich ~~Other~~
> 2.0µm	8.98 x 10^{-6}	1.85x10^{-6}			-
< 2.0µm	1.23 x 10^{-6}	4.46x 10^{-7}			9.44 x 10^{-8}

Comments: Lightly loaded, noticeably higher concentration of Si particulates (quartz).

70899
9/16/77

Particulate Analyses Form - DRI

Sample Identification Modesto - 35

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	4.80×10^{3}	-			
10μm - 20μm	4.80×10^{3}	-			
10μm - 5μm	2.88×10^{4}	9.61×10^{3}			
5μm - 2μm	8.16×10^{4}	1.63×10^{5}	(9.01×10^{4})[1]		
2μm - 1μm	8.11×10^{5}	5.40×10^{5}			
1μm - 0.5μm	9.01×10^{4}	3.60×10^{5}			
0.5μm - 0.2μm	-	1.44×10^{6}			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	2.13×10^{-5}	4.21×10^{-6}	(5.76×10^{-6})[1]		
< 2.0μm	3.22×10^{-6}	6.97×10^{-7}			

Comments: Metal particulate Cu,Zn

4578

4/24/76

Particulate Analyses Form - DRI

Sample Identification Modesto 36

Concentration Analysis:

	Particulate Type ($n\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm					
10μm - 20μm	4.80×10^3	-			
10μm - 5μm	1.92×10^4	9.61×10^3			
5μm - 2μm	4.80×10^3	6.25×10^4		$(9.01 \times 10^4)^1$	
2μm - 1μm	1.80×10^5	1.80×10^5			
1μm - 0.5μm	1.80×10^5	4.50×10^5			
0.5μm - 0.2μm	-	1.17×10^6			

Mass Analyses:

	Particulate Type ($gm\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	1.86×10^{-5}	3.52×10^{-6}		$(2.81 \times 10^{-6})^1$	
< 2.0μm	1.08×10^{-6}	2.89×10^{-7}			

Comments: Salt particulate rich in S and Na.

1849
3/1/76

Particulate Analyses Form - DRI

Sample Identification Woodland - 19

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$) Mineral	Carbonaceous	Metal	Salt	Other
> 20µm	-	-			
10µm - 20µm	-	-			
10µm - 5µm	4.80×10^3	-		$(4.81 \times 10^3)^1$	
5µm - 2µm	2.40×10^4	1.5×10^5	$(9.01 \times 10^4)^1$		
2µm - 1µm	2.71×10^5	6.31×10^5			
1µm - 0.5µm	1.80×10^5	7.21×10^5			
0.5µm - 0.2µm	-	6.76×10^6			

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$) Mineral	Carbonaceous	Metal	Salt	Other
> 2.0µm	1.68×10^{-6}	1.98×10^{-6}	$(9.21 \times 10^{-6})^1$		(1.77×10^{-7})
< 2.0µm	1.06×10^{-6}	4.56×10^{-7}			

Comments: Salts rich in Na & S quite common. One Metal particulate (~2.9µm) rich in Cu, Zn, Ni, Na.

2845
5/1/77

Particulate Analyses Form - DRI

Sample Identification Woodland 20

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	-	-			
10μm - 5μm	4.80×10^3	-		$(4.81 \times 10^3)^1$	
5μm - 2μm	1.44×10^4	9.13×10^4	$(1.80 \times 10^5)^1$		
2μm - 1μm	3.61×10^5	2.71×10^5			
1μm - 0.5μm	3.61×10^5	7.22×10^5			
0.5μm - 0.2μm	-	3.52×10^6			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	7.38×10^{-7}	1.45×10^{-6}	$(4.78 \times 10^{-6})^1$		$(1.23 \times 10^{-6})^1$
< 2.0μm	1.24×10^{-6}	3.16×10^{-7}			

Comments: One particulate of Cu,Zn, Na (2.1μm) and one of Mg,Pb (1.6μm) noted at 5000x. One particulate rich in P,Na,K, and Cu (6.25μm) noted at 1000x.

2501
11/2/76

Particulate Analyses Form - DRI

Sample Identification Woodland 21

Concentration Analysis:

	Particulate Type ($n\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Flyash ~~Other~~
> 20µm	-	-			
10µm - 20µm	4.81×10^3	-			
10µm - 5µm	7.70×10^4	9.62×10^3			
5µm - 2µm	1.20×10^5	2.45×10^5			
2µm - 1µm	4.25×10^5	1.45×10^6			$(9.61 \times 10^3)^1$
1µm - 0.5µm	4.25×10^4	2.53×10^6			
0.5µm - 0.2µm	-	1.56×10^7			

Mass Analyses:

	Particulate Type ($gm\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Flyash ~~Other~~
> 2.0µm	2.74×10^{-5}	5.61×10^{-6}	$(9.74 \times 10^{-7})^1$		$(1.05 \times 10^{-7})^1$
< 2.0µm	4.68×10^{-6}	1.53×10^{-6}			

Comments: Four particulates of metal observed- Fe(2µm), FeS (1.5µm), Ni (5.3µm) & Cu, Zn (1.2µm). Carbon particulates greater than 0.2µm (ie 0.3 &0.4) showing up quite frequently. Probably a unique source from previous samples (resulting in higher $\bar{d}$ i.e. higher mass contribution).

2084
5/18/76

Particulate Analyses Form - DRI

Sample Identification Woodland 22

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	4.81×10^{3}	-			
10μm - 5μm	9.62×10^{3}	-			
5μm - 2μm	4.33×10^{4}	1.49×10^{5}			
2μm - 1μm	1.26×10^{6}	3.61×10^{5}			
1μm - 0.5μm	3.60×10^{5}	8.12×10^{5}			
0.5μm - 0.2μm	-	2.80×10^{6}			

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	7.46×10^{-6}	2.30×10^{-6}	$(1.33\times10^{-6})^{1}$		
< 2.0μm	5.85×10^{-6}	5.33×10^{-7}	$(1.11\times10^{-6})^{1}$		

Comments: One particulate of Cu,Zn, observed at 1000x (4μm) and one of Cu,Zn, Ni at 5Kx (1.3μm).

2055
5/6/76

Particulate Analyses Form - DRI

Sample Identification Woodland 23

Concentration Analysis:

	Particulate Type ($n\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	1.44×10^4	-			
10μm - 5μm	5.28×10^4	4.80×10^3			
5μm - 2μm	7.68×10^4	1.87×10^5			
2μm - 1μm	1.17×10^6	2.70×10^5			
1μm - 0.5μm	5.40×10^5	1.89×10^6			
0.5μm - 0.2μm	-	4.51×10^6			

Mass Analyses:

	Particulate Type ($gm\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	3.73×10^{-5}	3.80×10^{-6}	$(1.61 \times 10^{-7})^1$		
< 2.0μm	4.82×10^{-6}	9.38×10^{-7}			

Comments: One particulate of Cu,Zn (2μm) noted at 1000x.

109863
11/3/77

Particulate Analyses Form - DRI

Sample Identification Woodland 24

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	-	-			
10μm - 5μm	2.41×10^4	9.61×10^3			
5μm - 2μm	2.41×10^4	6.73×10^4			
2μm - 1μm	3.61×10^5	3.60×10^5			
1μm - 0.5μm	1.80×10^5	6.30×10^5			
0.5μm - 0.2μm	-	1.35×10^6			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	$9.20 \text{x} 10^{-6}$	$3.94 \text{x} 10^{-6}$	$(5.53 \text{x} 10^{-6})^1$		
< 2.0μm	$1.81 \text{x} 10^{-6}$	$6.33 \text{x} 10^{-7}$			

Comments: One particulate (6.5μm) of Cu,Zn observed at low magnification.

11/2/76

Particulate Analyses Form - DRI

Sample Identification Live Oak -007

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Flyash ~~Other~~
> 20μm	$5.17x10^3$	-			
10μm - 20μm	-	-			
10μm - 5μm	$2.07x10^4$	$1.54x10^4$			
5μm - 2μm	$9.82\ x10^4$	$9.26x10^4$			
2μm - 1μm	$3.87\ x10^5$	$5.80x10^5$	$(9.67x10^4)^1$		$(5.16x10^3)^1$
1μm - 0.5μm	-	$8.70x10^5$			$(9.67x10^4)^1$
0.5μm - 0.2μm	-	$7.93x10^6$			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Flyash ~~Other~~
> 2.0μm	$2.23\ x10^{-5}$	$3.69x10^{-6}$			$(5.62x10^{-8})^1$
< 2.0μm	$2.16x10^{-6}$	$5.04x10^{-7}$	$(9.10x10^{-7})^1$		

Comments: Mineral mostly Si rich, but also contain Fe, Al, and occasionally other metals. Many carbon particulates ∿ 5-2 μm. One particulate (1.7μm) rich in Ti,V and Fe observed.

488
10/15/76

Particulate Analyses Form - DRI

Sample Identification Live Oak -008

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20µm	-	-			
10µm - 20µm	1.92×10^{4}	-			
10µm - 5µm	7.67×10^{4}	2.40×10^{4}	(4.81×10^{3})[1]		
5µm - 2µm	4.31×10^{4}	2.89×10^{4}			
2µm - 1µm	8.11×10^{5}	1.81×10^{4}			
1µm - 0.5µm	-	9.04×10^{5}			
0.5µm - 0.2µm	-	1.71×10^{7}			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0µm	5.90×10^{-5}	6.19×10^{-6}	(3.6×10^{-6})[1]		
< 2.0µm	3.81×10^{-6}	3.45×10^{-7}			

Comments: Similar to 007 but more heavily loaded. Single particle ($\sim$ 5.5µm) rich in Cu and Zn.

[1] Based on very low sample size

439
8/4/76

Particulate Analyses Form - DRI

Sample Identification Live Oak 009

Concentration Analysis:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (n cm^{-2})				
> 20μm	-	-			
10μm - 20μm	-	4.81×10^3			
10μm - 5μm	2.88×10^4	1.44×10^4			
5μm - 2μm	6.73×10^4	5.77×10^4	$(4.81 \times 10^3)^1$		
2μm - 1μm	1.80×10^5	3.61×10^5			
1μm - 0.5μm	9.00×10^4	1.08×10^6			
0.5μm - 0.2μm	-	4.60×10^6			

Mass Analyses:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (gm cm^{-2})				
> 2.0μm	7.40×10^{-6}	7.04×10^{-6}	$(3.38 \times 10^{-7})^1$		
< 2.0μm	9.40×10^{-7}	6.48×10^{-7}			

Comments: Mixed particulate minerals - Si, ASi K (feldspars). (Most predominate), Al.Si.K. Cu.Fe. (clay). Largest carbon particulates show some structure suggestive of faunal origin.

11680
11/8/76

Particulate Analyses Form - DRI

Sample Identification Chico 002

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	1.04×10^{4}	0			
10μm - 20μm	1.04×10^{4}	5.16×10^{3}			
10μm - 5μm	9.29×10^{4}	2.5×10^{4}			
5μm - 2μm	1.14×10^{5}	9.80×10^{4}			
2μm - 1μm	7.76×10^{5}	2.59×10^{5}			
1μm - 0.5μm	1.36×10^{6}	9.01×10^{5}			
0.5μm - 0.2μm	9.70×10^{4}	1.94×10^{7}			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	6.78×10^{-5}	7.70×10^{-6}			
< 2.0μm	3.27×10^{-6}	5.30×10^{-7}			

Comments: Two Fe and Ni-rich particulates observed.

101652
12/21/77

Particulate Analyses Form - DRI

Sample Identification Live Oak 010

Concentration Analysis:

	Particulate Type ($n\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	-	-			
10μm - 20μm	1.44×10^4	-			
10μm - 5μm	1.44×10^4	4.80×10^3			
5μm - 2μm	4.80×10^3	9.60×10^3			
2μm - 1μm	-	9.00×10^4			
1μm - 0.5μm	-	3.60×10^4			
0.5μm - 0.2μm	9.01×10^4	2.61×10^6			

Mass Analyses:

	Particulate Type ($gm\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	3.84×10^{-5}	1.16×10^{-6}			
< 2.0μm	9.82×10^{-10}	1.04×10^{-7}			

Comments: Some Carbon again shows structure suggesting biological origin.

448
10/3/76

Particulate Analyses Form - DRI

Sample Identification Live Oak 011

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$) Mineral	Carbonaceous	Metal	Salt	Other
> 20µm	4.50×10^3	4.80×10^3			
10µm - 20µm	4.50×10^3	-			
10µm - 5µm	3.15×10^4	-	$(9.01 \times 10^4)^1$		
5µm - 2µm	2.70×10^4	1.92×10^4			
2µm - 1µm	9.01×10^4	2.71×10^5			
1µm - 0.5µm	-	2.71×10^5			
0.5µm - 0.2µm	-	3.61×10^6			

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$) Mineral	Carbonaceous	Metal	Salt	Other
> 2.0µm	4.36×10^{-5}	7.91×10^{-6}	$(1.74 \times 10^{-5})^1$		
< 2.0µm	2.70×10^{-7}	1.64×10^{-7}			

Comments: Carbon particulates usually angular and more similar to mineral particulate morphology. Metal particulate, Cu Zn.

636
6/18/77

Particulate Analyses Form - DRI

Sample Identification Live Oak -12

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Flyash ~~Other~~
> 20µm	-	-			
10µm - 20µm	1.92×10^4	-			
10µm - 5µm	1.44×10^4	-			
5µm - 2µm	2.40×10^4	2.88×10^4			
2µm - 1µm	6.31×10^5	-			(9.01×10^4)[1]
1µm - 0.5µm	9.01×10^4	4.51×10^5			
0.5µm - 0.2µm	-	7.21×10^6			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Flyash
> 2.0µm	3.40×10^{-5}	7.49×10^{-7}			(9.82×10^{-7})[1]
< 2.0µm	2.59×10^{-6}	1.53×10^{-7}			

Comments: Mineral components unchanged, singular flyash particulate rich in Si,Cu,Na. One near spherical carbon particulate observed.

---

[1] Based on a very low sample size.

345301
10/22/77

Particulate Analyses Form - DRI

Sample Identification Chico-001

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	0	0	0		
10μm - 20μm	2.46×10^{4}	0	$(6.14\times10^{3})_1$		
10μm - 5μm	5.53×10^{4}	4.29×10^{4}	$(2.46\times10^{4})_1$		
5μm - 2μm	1.29×10^{5}	1.53×10^{5}	0		
2μm - 1μm	6.18×10^{5}	4.66×10^{5}	$(3.87\times10^{5})_1$		
1μm - 0.5μm	1.16×10^{6}	1.99×10^{5}	$(3.10\times10^{5})_1$		
0.5μm - 0.2μm	2.32×10^{5}	9.63×10^{6}	0		

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	3.10×10^{-5}	7.75×10^{-6}	$(1.65\times10^{-5})_1$		
< 2.0μm	2.65×10^{-6}	4.62×10^{-7}	$(1.56\times10^{-6})_1$		

Comments: Metal particulate estimates based on small sample size - Cu, Fe and Zn most common. All amounts of material are comparable because identical preparation procedures were used for all samples.

12964
5/1/77

Particulate Analyses Form - DRI

Sample Identification Chico 003

Concentration Analysis:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (n cm^{-2})				
> 20μm	0	0			
10μm - 20μm	5.16×10^{3}	0			
10μm - 5μm	5.16×10^{3}	5.16×10^{3}			
5μm - 2μm	1.55×10^{4}	3.09×10^{4}			
2μm - 1μm	2.90×10^{5}	0			
1μm - 0.5μm	9.67×10^{4}	2.9×10^{5}			
0.5μm - 0.2μm	1.93×10^{5}	2.9×10^{5}			

Mass Analyses:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (gm cm^{-2})				
> 2.0μm	3.88×10^{-6}	1.26×10^{-6}			
< 2.0μm	7.32×10^{-7}	7.25×10^{-8}			

Comments: Sample very lightly loaded.

71024
9/28/77

Particulate Analyses Form - DRI

Sample Identification Chico 004

Concentration Analysis:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (n cm^{-2})				
> 20µm	0	0			
10µm - 20µm	7.74×10^3	0			
10µm - 5µm	7.74×10^3	0			
5µm - 2µm	3.48×10^4	2.32×10^4			
2µm - 1µm	3.87×10^5	1.29×10^5			
1µm - 0.5µm	0	2.58×10^5			
0.5µm - 0.2µm	5.16×10^5	2.58×10^5			

Mass Analyses:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (gm cm^{-2})				
> 2.0µm	7.43×10^{-6}	4.61×10^{-7}			
< 2.0µm	3.27×10^{-7}	6.24×10^{-7}			

Comments:

8247

1/13/76

Particulate Analyses Form - DRI

Sample Identification Chico 005

Concentration Analysis:

Size Range	Particulate Type (n cm^{-2})				
	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	0	0			
10μm - 20μm	7.74×10^{3}	0			
10μm - 5μm	3.10×10^{4}	3.87×10^{3}			
5μm - 2μm	5.97×10^{4}	9.28×10^{4}			
2μm - 1μm	1.07×10^{6}	1.94×10^{5}			
1μm - 0.5μm	4.84×10^{5}	1.16×10^{6}			
0.5μm - 0.2μm	2.91×10^{5}	1.16×10^{7}			

Mass Analyses:

Size Range	Particulate Type (gm cm^{-2})				
	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	8.81×10^{-6}	1.93×10^{-6}			
< 2.0μm	2.85×10^{-6}	2.25×10^{-7}			

Comments:

12972
6/18/77

Particulate Analyses Form - DRI

Sample Identification Chico 006

Concentration Analysis:

	Particulate Type ($n\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	0	0			
10μm - 20μm	0	0			
10μm - 5μm	$1.55x10^{4}$	$5.15x10^{3}$			
5μm - 2μm	$5.67x10^{4}$	$1.65x10^{5}$			
2μm - 1μm	$2.71x10^{6}$	$2.90x10^{5}$			
1μm - 0.5μm	$1.93x10^{6}$	$1.20x10^{6}$			
0.5μm - 0.2μm	0	$3.37x10^{6}$			

Mass Analyses:

	Particulate Type ($gm\ cm^{-2}$)				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	$6.21x10^{-6}$	$3.74x10^{-6}$			
< 2.0μm	$2.74x10^{-5}$	$3.15x10^{-7}$			

Comments:

10/21/76
11700

Particulate Analyses Form - DRI

Sample Identification Merced II (47)

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	--	--			
10μm - 20μm	4.81×10^{3}	--			
10μm - 5μm	1.92×10^{4}	4.79×10^{3}			
5μm - 2μm	1.92×10^{4}	1.10×10^{5}			
2μm - 1μm	5.40×10^{4}	2.70×10^{5}			
1μm - 0.5μm	6.30×10^{4}	3.61×10^{5}			
0.5μm - 0.2μm	1.80×10^{5}	5.05×10^{6}			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	1.34×10^{-5}	3.40×10^{-6}			
< 2.0μm	2.17×10^{-6}	1.46×10^{-7}			

Comments: One large fiber observed (30 μm x 8 μm), probably organic. one lead particulate observed, d = 3.0 μm. One large particle rich in P, S and Si, football shaped, d = 7μm

12/14/76
11841

Particulate Analyses Form - DRI

Sample Identification Merced II - 48

Concentration Analysis:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (n cm^{-2})				
> 20μm	--	--			
10μm - 20μm	--	--			
10μm - 5μm	3.85×10^4	4.81×10^3			
5μm - 2μm	6.25×10^4	2.02×10^5			
2μm - 1μm	7.20×10^5	1.32×10^6			
1μm - 0.5μm	3.60×10^5	4.91×10^6			
0.5μm - 0.2μm		1.01×10^7			

Mass Analyses:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (gm cm^{-2})				
> 2.0μm	1.33×10^{-5}	5.10×10^{-6}			
< 2.0μm	3.23×10^{-6}	2.20×10^{-6}			

Comments: Some carbon appears to be fibrous and organic in origin (> 2.0μm). Many smaller particles are agglomerates.

6/18/76
10133

Particulate Analyses Form - DRI

Sample Identification Merced II - 49

Concentration Analysis:

Size Range	Particulate Type (n cm^{-2})				
	Mineral	Carbonaceous	Metal	Salt	Other
> 20µm	--	--			
10µm - 20µm	4.81×10^{3}	--			
10µm - 5µm	1.44×10^{4}	4.80×10^{3}			
5µm - 2µm	4.81×10[illegible]	2.06×10^{5}			
2µm - 1µm	1.26×10^{6}	6.31×10^{5}			
1µm - 0.5µm	4.50×10^{5}	1.99×10^{6}			
0.5µm - 0.2µm	2.70×10^{5}	3.24×10^{6}			

Mass Analyses:

Size Range	Particulate Type (gm cm^{-2})				
	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0µm	8.25×10^{-6}	3.48×10^{-6}			
< 2.0µm	4.43×10^{-6}	1.04×10^{-6}			

Comments: A number of small carbon particles are agglomerates.

2/24/77
11853

Particulate Analyses Form - DRI

Sample Identification Merced (II) 50

Concentration Analysis:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (n cm^{-2})				
> 20μm	--	--			
10μm - 20μm	--	--			
10μm - 5μm	--	4.81×10^3			
5μm - 2μm	1.11×10^5	1.68×10^5			
2μm - 1μm	6.30×10^5	3.61×10^5			
1μm - 0.5μm	5.40×10^5	1.89×10^6			
0.5μm - 0.2μm	--	3.79×10^6			

Mass Analyses:

Size Range	Mineral	Carbonaceous	Metal	Salt	Other
	Particulate Type (gm cm^{-2})				
> 2.0μm	3.64×10^{-6}	2.73×10^{-6}			
< 2.0μm	3.09×10^{-6}	1.17×10^{-6}			

Comments:

11851
2/12/77

Particulate Analyses Form - DRI

Sample Identification Merced (II) 51

Concentration Analysis:

	Particulate Type (n cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	--	--			
10μm - 20μm	--	--			
10μm - 5μm	$4.80x10^{3}$	$1.44x10^{4}$			
5μm - 2μm	$1.92x10^{4}$	$7.69x10^{4}$			
2μm - 1μm	$2.70x10^{5}$	$9.01x10^{4}$			
1μm - 0.5μm	$3.60x10^{5}$	$1.08x10^{6}$			
0.5μm - 0.2μm	$1.80x10^{5}$	$8.29x10^{6}$			

Mass Analyses:

	Particulate Type (gm cm^{-2})				
Size Range	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	$3.62x10^{-6}$	$3.05x10^{-6}$			
< 2.0μm	$7.76x10^{-7}$	$3.88x10^{-7}$			

Comments: Very lightly loaded sample. One large particle, d = 7, of SCaSiNaFe observed. One particle rich in sulfur, d = 0.6μm, and one lead, including K and Si, d = 1.8μm, also observed.

4/6/76
4388

Particulate Analyses Form - DRI

Sample Identification Merced (II) - 52

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	--	--			
10μm - 20μm	9.60×10^3	--			
10μm - 5μm	9.60×10^3	3.86×10^3			
5μm - 2μm	1.44×10^4	6.55×10^4			
2μm - 1μm	5.40×10^5	3.61×10^5			
1μm - 0.5μm	6.30×10^5	1.08×10^6			
0.5μm - 0.2μm	3.60×10^5	2.44×10^6			

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	1.34×10^{-5}	1.29×10^{-6}			
< 2.0μm	2.12×10^{-6}	7.19×10^{-7}			

Comments: A few large mineral particles have significantly increased the estimated mass concentration of this sample.

6/6/77
13007

Particulate Analyses Form - DRI

Sample Identification Sample 55 Visalia

Concentration Analysis:

Size Range	Particulate Type ($n\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 20μm	--	--			
10μm - 20μm	1.61×10^4	--			
10μm - 5μm	8.07×10^4	2.88×10^4			
5μm - 2μm	1.45×10^5	4.61×10^5			
2μm - 1μm	1.80×10^6	3.60×10^5			
1μm - 0.5μm	1.62×10^6	4.14×10^6			
0.5μm - 0.2μm	5.41×10^5	4.30×10^6			

Mass Analyses:

Size Range	Particulate Type ($gm\ cm^{-2}$)				
	Mineral	Carbonaceous	Metal	Salt	Other
> 2.0μm	4.99×10^{-5}	1.77×10^{-5}			
< 2.0μm	6.01×10^{-6}	1.35×10^{-6}			

Comments: Very heavily loaded. Smaller size minerals comparatively high concentration of Si. Overall, there is a high carbon to mineral ratio. Source of carbon is indeterminate, probably material that formed on filter surface.

APPENDIX C

CHEMICAL/ELEMENTAL CONCENTRATIONS

This appendix presents individual variable concentrations for each of the eight Phase I sites and six Phase II sites.

TABLE C-1. VARIABLE CONCENTRATIONS MEASURED AT BAKERSFIELD (FLOWER)

Date		Variable concentration, ug/m^3																				Avg wind spd, mph	Days since >0.25 in. rain	Atmos mois-ture
		Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP			
1977	7/6[a]	2.23	3.44	b	3.89	2.54	.27	.06	.18	.30	4.92	-	.08	.03	.08	.17	1.16	.02	b	b	140	6.6	133	32
	7/18[a]	1.36	2.25	b	4.03	1.30	.14	.06	.18	.21	2.76	-	.12	.66	.10	.08	.32	-	b	b	92	8.1	145	42
	8/11[a]	2.40	3.32	b	5.64	2.58	.30	.10	.20	.28	5.93	-	.19	.60	.17	.07	1.33	.04	b	b	157	7.5	169	30
	8/24[a]	1.75	2.80	b	3.11	1.70	.16	.08	.13	.25	3.92	-	.10	.41	.35	-	.47	-	b	b	112	7.6	7	20
	9/4	2.13	3.54	1.26	7.55	1.87	.15	.06	.28	.18	4.10	-	.14	.38	-	.03	1.44	.02	8.35	-	133	6.3	18	31
	9/28	2.01	3.19	.82	4.50	1.67	.17	.06	.22	.30	3.98	-	.16	.36	.01	.30	1.00	-	8.75	-	121	6.6	32	21
	10/16	3.12	3.35	1.06	4.60	3.31	.39	.07	.23	.33	8.18	-	.20	.29	.09	.50	3.00	.01	8.76	-	217	5.8	50	27
	10/22	2.37	3.89	1.18	6.94	2.68	.22	.07	.17	.30	5.59	-	.20	.26	-	.56	3.14	.03	14.34	-	194	4.9	56	21
	11/9	1.59	2.73	1.12	10.62	1.78	.14	.07	.16	.23	3.49	-	.20	.24	-	.55	3.19	.03	17.76	-	210	6.3	74	3
	11/27	1.62	2.14	1.19	7.97	1.82	.13	.09	.14	.26	4.39	-	.17	.33	-	.27	2.13	.01	-	-	221	4.9	92	11
	12/9[a]	1.66	2.68	b	14.71	1.73	.15	.13	.22	.27	4.04	-	.22	.30	-	.58	3.55	.07	b	b	208	4.8	114	6
	12/27[a]	.31	-	b	4.55	.14	-	.03	.01	.01	.22	-	.07	.24	-	.24	1.36	-	b	b	46	7.3	0	5
1978	1/3[a]	.82	1.08	b	4.26	.65	.03	.06	.09	.14	1.31	-	.09	.25	-	.32	1.56	-	b	b	63	6.8	6	5
	1/26[a]	1.54	2.58	b	8.24	1.78	.09	.08	.17	.21	3.02	-	.20	.20	-	.58	2.43	.02	b	b	174	3.2	10	7
	2/7	.47	.42	.39	2.88	.25	-	-	.04	.06	.61	-	-	.29	-	.55	1.67	1.30	8.97	-	43	8.5	22	6
	3/3	.52	.77	.52	2.99	.28	.03	.03	.12	.12	1.01	-	.03	.27	-	.07	.89	.01	8.30	-	54	5.0	20	10
	3/15	1.64	2.48	1.03	6.68	1.56	.15	.18	.20	.25	2.71	-	.14	.26	-	.08	1.87	.02	16.54	-	161	5.9	11	9
	3/27	1.55	1.84	1.37	10.81	1.56	.15	.13	.25	.28	3.51	-	.18	.33	-	.20	1.43	.02	22.11	-	184	6.3	6	9
	4/14	.77	.74	.77	5.20	.51	.04	.08	.13	.16	1.53	-	.18	.24	-	-	-	-	18.20	-	96	9.5	8	15
	4/20	.58	.72	.61	2.38	.31	.03	.02	.09	.14	1.10	-	.02	.20	-	.16	.03	-	6.45	-	70	9.5	14	16
	5/3	2.13	3.30	.91	5.05	1.75	.16	.05	.24	.26	3.66	-	.18	.31	-	-	-	-	5.00	-	174	9.1	27	23
	5/8	2.17	3.32	.78	3.52	2.09	.22	.05	.18	.28	4.01	-	.14	.31	-	-	.45	-	8.67	-	190	6.6	63	37
	5/14	2.43	3.62	.80	3.97	2.49	.25	.08	.27	.37	5.10	-	.23	1.28	.04	-	-	-	9.11	-	140	8.8	38	31
	6/19	1.80	2.70	1.05	4.32	1.90	.10	.03	.16	.19	3.27	-	.15	.36	-	-	.10	-	8.45	-	151	6.5	74	30
	mean	1.62	2.37	.93[c]	5.77	1.57	.15	.07	.17	.22	3.47	.12	14	.35	.04	.22	1.35	.07	10.61[c]	c	139.6	6.8	49.5	18.6
	std dev	.73	1.15	.28[c]	2.98	.86	.10	.04	.07	.09	1.86	.00	.06	b	b	.22	1.11	.26	5.66[c]	.00[c]	56.8	1.6	49.1	11.7

[a] Blank filter concentrations not available.

[b] No analysis performed.

[c] 16 samples.

- = minimum detectable concentrations

TABLE C-2. VARIABLE CONCENTRATIONS MEASURED AT TAFT

Date		Variable concentration, ug/m^3																				Avg wind spd, mph	Days since 0.25 in. rain	Atmos mois- ture
		Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	SO$_4^=$	BSO	TSP			
1977	7/6[a]	1.37	2.48		3.72	2.23	.21	.06	.17	.28	3.17	-	.17	.09	.77	.24	-	-			100			
	7/18[a]	1.61	2.91		1.75	1.65	.26	.11	.15	.30	3.81	-	.11	.19	.81	-	-	-			99			
	8/10[a]	1.71	2.75		6.08	2.62	.30	.06	.20	.37	4.50	-	.11	.09	.80	.09	-	-			142			
	8/17[a]	.67	.89		3.31	.43	.15	.04	.02	.13	1.56	-	.04	.13	.76	.06	.78	-			62			
	9/4[a]	1.23	1.82		5.04	1.49	.20	.06	.11	.28	2.73	-	.11	.06	.74	.09	-	-			80			
	9/27	1.37	2.53	.82	3.30	1.25	.06	.04	.16	.30	2.97	-	.10	.02	-	-	.20	-	5.1		84			
	10/9	2.01	3.50	.95	3.67	2.99	.14	.02	.17	.31	4.15	-	.10	.02	-	-	-	-	4.4		123			
	10/28	2.40	3.92	1.08	3.70	3.27	.28	.02	.26	.37	5.82	-	.22	.06	-	-	-	-	7.1		175			
	11/9	1.52	1.95	1.52	9.51	2.41	.15	.06	.23	.30	4.07	-	.19	.02	-	.06	.78	-	12.3		165			
	11/27	.60	1.19	.62	3.11	.48	-	.02	.04	.14	1.04	-	.04	-	-	-	-	-	7.7		56			
	12/9	1.01	1.24	1.22	7.73	1.07	.13	.06	.15	.24	2.85	-	.13	.02	-	.09	.73	-	12.6		151			
	12/27	.27	.39	.56	1.62	-	-	-	.06	.08	.31	-	-	-	-	-	.73	-	4.6		29			
1978	1/3	.65	.67	.74	4.37	.37	.04	.04	.17	.24	1.47	-	.07	.09	-	-	.76	-	7.4		72			
	1/25	.80	.64	1.19	7.88	1.33	.08	.06	.18	.32	2.37	-	.10	.04	-	.04	-	-	16.1		137			
	2/13	.46	.27	.48	2.90	.17	-	.04	.02	.06	.52	-	.08	.04	-	-	-	-	7.5		35			
	3/2	.48	.60	.64	2.28	.12	.06	.02	.17	.20	1.04	-	-	.04	-	.19	.73	.27	5.5		51			
	3/17	1.47	2.37	1.12	4.50	2.00	.13	.04	.20	.35	3.65	-	.18	.11	-	-	-	-	8.7		117			
	3/28	.83	1.08	1.08	4.20	1.26	.08	.04	.14	.24	2.01	-	.08	.18	-	-	-	-	9.6		103			
	4/2	.55	.96	.68	2.79	.74	.06	.02	.12	.16	1.29	-	.06	.02	-	-	-	-	6.3		55			
	4/14	.99	1.40	.87	4.32	.91	.15	.04	.14	.25	2.48	-	.04	.11	-	-	-	.68	7.5		95			
	4/20	.84	1.49	.91	3.07	.65	.04	.04	.13	.24	1.86	-	.02	.09	-	-	-	-	5.4		62			
	5/2	1.04	1.50	.92	3.20	1.32	.09	.04	.20	.33	2.49	-	.16	.13	-	-	.31	-	5.9		83			
	5/9	2.31	3.54	.83	3.24	2.48	.28	.04	.26	.39	5.72	-	.16	.07	-	-	.05	-	7.2		180			
	6/9	1.67	2.60	.76	2.44	1.99	.25	.02	.14	.28	3.92	-	.09	.06	-	-	-	-	4.9		108			
	6/19	1.48		.89	3.98	1.74	.19	.02	.19	.32	3.69	-	.08	.08	-	-	-	-	4.5		94			
	mean	1.14	1.72	.89	4.04	1.33	.11	.03	.16	.26	2.67	-	.10	.06	-	.03	.22	.06	7.52		98.8			
	std dev	.62	1.09	.25	2.09	.95	.09	.02	.06	.09	1.58		.06			.04	.32		3.09		45.6			

[a] Blank filters not available; data not included in means.

- = minimum detectable concentrations

TABLE C-3. VARIABLE CONCENTRATIONS MEASURED AT KERN REFUGE

Date	Variable concentration, ug/m^3																				Avg wind spd, mph	Days since ·0.25 in. rain	Atmos mois-ture
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Pr	Pb	Cl	SO_4^-	BSO	TSP			
1977 7/6[a]	1.64	3.25		3.00	2.10	.11	.08	.19	.35	3.44	-	.03	.03	-	-	-	-			99			
7/18[a]	1.46	3.13		1.61	1.58	.09	.04	.21	.32	2.83	-	.06	.15	-	-	-	-			79			
8/11[a]	1.64	2.61		4.30	2.18	.12	.05	.17	.26	3.41	-	.07	.19	-	-	-	-			116			
8/17[a]	.88	1.64		3.33	1.11	.07	.05	.19	.25	1.83	-	.02	.25	-	-	-	-			67			
9/4[a]	1.28	2.43		2.38	1.60	.09	.05	.18	.30	2.45	-	-	.18	-	-	.21	-			66			
9/28[a]	.59	1.00		1.40	.07	.09	-	-	.09	1.29	-	-	.09	.54	-	-	-			50			
10/10[a]	1.27	2.80		2.08	1.48	.16	.05	.09	.25	2.82	-	.07	.25	.44	-	-	-			94			
10/27[a]	1.86	3.36		5.31	2.94	.24	.09	.09	.27	4.16	-	.09	.16	.86	-	-	-			127			
11/9[a]	1.23	2.08		4.61	1.32	.21	.05	.14	.25	2.78	-	.07	.23	.81	-	-	-			109			
12/9[a]	.68	.54		12.74	1.54	.20	.09	.11	.23	2.49	-	.16	.43	.81	-	.91	-			283			
12/27[a]	.09	.81		1.43	-	.09	.07	-	-	.02	-	-	.09	.79	-	.07	-			57			
1978 1/8[a]	.27	.56		1.51	-	.04	.02	-	.04	.29	-	-	-	-	.02	.07	-			52			
1/20[a]	.11	.74		1.30	-	-	-	-	-	-	-	-	-	-	-	-	-			33			
2/14[a]	.33	1.15		.77	-	.05	-	-	-	-	-	-	.10	-	-	-	-			20			
3/3[a]	.50	.77		1.16	.04	.04	-	.08	.08	-	-	-	.12	-	-	-	-			18			
3/15[a]	.52	1.05		1.11	.29	-	-	-	-	.06	-	-	.06	-	-	-	-			36			
3/27[a]	.70	.94		2.44	.33	.02	-	.06	.04	.18	-	-	.06	-	-	-	-			52			
4/27	.46	.73	.66	2.20	.21	.06	-	.08	.10	.29	-	-	.04	-	-	-	-			29			
5/2	.96	1.23	.75	3.18	67	.06	-	.15	.23	1.21	-	.08	.04	-	-	-	-			52			
5/8	.10	-	-	.08	-	.06	-	.14	.14	.04	-	-	.06	-	-	-	-			124			
6/7	1.84	3.41	.96	1.86	2.08	.24	.02	.22	.37	3.68	-	.09	.07	-	-	-	-			101			
6/14	1.84	3.55	.88	2.88	2.27	.19	-	.19	.34	3.62	-	.06	.09	-	.04	-	-			74			
mean	.96	1.80	.69	2.83	1.07	.11	.04	.11	.23	1.82	-	.05	.13	.23	.02	.06	-			91.1			
std dev	.62	1.19		2.56	.99	.09	.03	.07	.26	1.60		.05	.10	.36	.02	.19				61.7			

[a] Blank filters not available.

- = minimum detectable concentrations

TABLE C-4. VARIABLE CONCENTRATIONS MEASURED AT VISALIA

Date		Variable concentration, μg/m^3																			Avg wind spd, mph	Days since ·0.25 in. rain	Atmos moisture
		Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP		
1977	7/6	4.00	2.30	.77	2.13	3.27	.14	-	.08	.33	5.08	-	.12	.20	-	-	.30	.04	.3		129	8.5	56	33
	7/18	2.53	2.67	.24	2.15	3.48	.22	.02	.22	.34	5.47	-	.14	.22	-	.16	-	-	7.8		131	9.5	68	36
	8/11	2.94	2.84	.69	4.19	4.05	.22	-	.12	.39	6.04	-	.18	.16	-	-	.67	.10	5.2		164	7.1	91	24
	8/23	2.62	2.54	.73	3.46	3.78	.18	-	1.42	.37	5.86	-	.12	.14	-	.02	.26	.04	1.5		154	8.2	104	28
	9/4	1.94	2.02	.40	3.18	2.94	.12	-	.08	.28	4.13	-	.08	.14	-	.02	.56	.08	5.8		103	4.9	115	26
	9/28	3.02	3.06	.53	2.96	3.68	.31	-	.16	.39	7.17	-	.25	.29	-	.02	.81	.06	6.2		161	8.3	138	18
	10/10	2.52	2.52	.48	3.15	3.55	.17	-	.17	.31	5.42	-	.10	.15	-	.23	1.40	.13	5.2		153	4.3	152	22
	10/22[a]	3.49	3.51		5.52	3.03	.50	.04	.21	.39	6.68	-	.12	.23	.17	-	1.56	.12	7.2		213	3.0	164	16
	11/9[a]	2.02	2.16		6.38	1.01	.24	.04	.13	.33	3.92	-	.13	.13	.18	.44	2.86	.15	-		179	2.2	5	13
	11/27[a]	1.62	1.71		8.89	1.23	.26	.02	.15	.26	2.44	-	.11	.13	.13	.11	2.43	.28	4.1		232	2.2	22	8
	12/9	1.06	.99	.21	6.55	1.34	.09	.02	.14	.28	2.99	-	.09	.19	-	.21	1.63	.12	9.7		50	3.2	34	4
	12/28	.60	.44	-	1.62	.16	.05	-	.02	.16	1.20	-	.05	1.02	-	.25	1.76	.21	-		131	6.3	1	6
1978	1/4	.66	.50	.02	1.97	.55	.02	-	-	.02	1.02	-	-	.06	-	.16	.95	-	-		33	9.5	7	4
	1/26	.94	.69	.36	2.10	.85	.07	.02	.07	.16	2.32	-	.04	.08	-	-	1.06	.04	5.1		118	4.8	8	5
	2/7	.31	.19	-	1.50	-	.02	-	-	-	.60	-	-	.14	-	.12	.19	.60	-		29	10.2	0	6
	3/3	.44	.14	-	1.65	.12	-	-	-	-	.91	-	-	.06	-	-	-	1.77	5.4		33	10.2	0	9
	3/21	.51	.19	-	2.13	.21	.02	-	-	-	.95	-	-	.25	-	.16	.07	-	8.6		46	6.8	0	8
	3/27	1.50	1.34	.65	4.39	1.85	.14	.02	.12	.30	3.89	-	.05	.21	-	.30	.97	.09	4.3		136	6.0	8	9
	4/14	1.02	.98	.36	1.96	1.09	.07	.02	.11	.20	2.32	-	.09	.16	-	-	-	.93	1.5		66	9.8	9	16
	4/20	1.22	1.43	.41	1.56	1.02	.06	-	.09	.23	2.69	-	.14	.23	-	-	-	-	1.0		85	8.1	6	13
	5/2	1.46	1.56	.69	6.00	2.11	.12	.02	.14	.26	3.89	-	.14	.46	-	-	.60	.12	5.3		106	6.2	8	15
	5/14	1.77	1.97	.54	1.72	2.10	.09	.02	.13	.29	4.09	-	.02	.31	-	-	.33	-	4.8		122	7.9	20	26
	6/7	2.99	2.89	.48	2.14	3.94	.23	.02	.21	.30	6.84	-	.21	.69	-	-	-	.05	4.0		177	8.6	44	40
	6/21	2.77	2.68	1.10	4.10	4.60	.25	.05	.23	.50	6.96	-	.09	.18	-	-	.30	.02	6.5		175	8.6	58	11
	mean	1.75	1.61	.41	2.89	2.13	.17	.02	.17	.25	3.80	-	.09	.25	-	.08	.57	.21	4.21		109.6	7.5	44.1	17.1
	std dev	1.06	1.00	.30	1.45	1.54	.24	.01	.29	.14	2.17		.07	.23		.10	.55	.42	2.93		49.4	2.0	49.3	11.2

[a] Blank filters not available for elemental analysis data not included in means.

- = minimum detectable concentrations

TABLE C-5. VARIABLE CONCENTRATIONS MEASURED AT PARLIER

Date		Variable concentration,[a] ug/m^3																				Avg wind spd, mph	Days since 0.25 in. rain	Atmos moisture
		Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP			
1977	7/6[b]	2.74	4.06	c	1.94	2.24	.21	.08	.29	.31	4.02	-	.06	-	-	-	.33	-	c	c	125	8.5	56	33
	7/18[b]	3.43	5.29	c	1.99	2.37	.20	.13	.30	.43	4.84	-	.05	.13	-	-	-	-	c	c	149	9.5	68	36
	8/11	3.40	5.15	c	3.40	3.00	.30	.05	.35	.42	5.72	-	.08	.08	-	-	.08	-	10.80	-	190	7.1	91	24
	8/29	3.68	5.40	c	2.55	3.05	.25	.08	.28	.42	6.40	-	.10	.12	-	-	.30	-	3.83	-	193	7.2	109	27
	9/4	2.98	4.60	c	3.12	2.45	.22	.10	.32	.35	4.55	-	.08	.12	-	.02	-	-	6.30	-	129	4.9	115	26
	9/28	3.20	5.06	c	2.92	2.67	.28	.08	.25	.45	5.06	-	.10	.10	-	-	-	-	6.30	-	135	8.3	139	18
	10/10	3.18	5.20	c	2.82	2.60	.23	.05	.28	.38	5.06	-	.08	.08	-	-	.30	-	4.30	-	150	4.3	152	22
	10/22	3.23	4.88	c	4.28	3.04	.22	.10	.29	.39	4.96	-	.73	.49	-	.17	.19	-	4.85	-	181	3.0	164	16
	11/9	1.56	2.27	c	4.46	1.36	.08	.10	.25	.33	2.30	-	.08	.13	.13	.18	.96	-	4.85	-	114	2.2	5	13
	11/27	1.29	2.45	c	2.30	.95	.05	.05	.19	.14	1.46	-	-	.05	-	.05	.53	-	7.33	-	180	2.2	22	8
	12/3	1.58	2.76	c	4.02	1.42	.03	.05	.19	.51	2.38	-	.05	-	-	.19	-	-	11.20	-	259	5.2	28	7
	12/15	.68	1.23	c	.78	.30	-	-	.02	.02	.60	-	-	-	-	-	-	.43	5.42	-	61	10.9	40	6
1978	1/8	.57	.50	c	1.65	.05	-	.02	.10	-	.19	-	-	.02	-	-	-	-	6.92	-	37	7.6	4	7
	1/26	1.04	2.43	c	1.50	-	-	-	.08	.20	.54	-	-	.08	-	-	1.20	-	8.53	-	82	4.8	8	5
	2/25	.66	1.16	c	3.40	.58	-	.05	.08	.05	.07	-	-	.08	-	.03	.42	-	20.00	-	104	5.2	13	6
	3/3	.48	1.31	c	.34	.05	-	.02	.05	.02	.02	-	-	.02	-	-	-	.80	6.14	-	25	10.2	0	9
	3/15	.85	1.36	c	1.43	.36	-	.05	.12	.12	.75	-	-	.14	-	-	-	-	5.66	-	60	4.5	5	10
	3/27	.83	1.23	c	.70	.18	.02	.10	.13	.15	.70	-	-	.25	-	-	-	-	2.54	-	65	6.0	8	9
	4/14	.68	.85	c	1.36	.05	.05	.05	.12	.14	.70	-	-	-	-	-	-	-	4.90	-	39	9.8	9	16
	4/20	.64	.76	c	1.47	.16	.02	.07	.12	.07	.88	-	-	-	-	-	-	.02	-	-	51	8.1	6	13
	5/2	1.80	1.99	c	11.10	1.26	.12	.07	.33	.36	2.35	-	.07	.05	-	.12	-	-	4.90	-	116	6.2	8	15
	5/14	1.89	3.78	c	1.35	1.50	.11	.11	.28	.37	3.02	-	-	.03	-	-	-	-	3.60	-	156	7.9	20	26
	6/1	3.29	4.84	c	3.50	2.76	.31	.19	.40	.53	6.14	-	.12	.12	-	-	-	-	7.16	-	211	9.9	38	25
	6/7	2.99	4.47	c	1.65	2.39	.22	.13	.04	.48	5.16	-	.04	.13	-	-	.22	-	11.2	-	206	8.6	44	40
	mean	1.84	2.89	c	2.73	1.37	.12	.07	.19	.27	2.68	.12	.07	.10	.02	.04	.20	.07	6.67		124.7	6.6	46.7	15.8
	std dev	1.16	1.76	c	2.22	1.17	.11	.04	.11	.18	2.26	.00	.15	.11	c	.06	.33	.19	4.02	.00	66.8	2.6	54.3	9.2

[a] Blank filter elemental concentrations not available; sulfate and BSO blank concentrations provided by the Fresno County APCD.

[b] Fresno APCD blank filter concentrations not available; data not included in mean.

[c] No analysis performed.

- = minimum detectable concentrations

TABLE C-6. VARIABLE CONCENTRATIONS MEASURED AT FRESNO (CAL STATE)

Date		Variable concentration,[a] ug/m^3																			Avg wind spd, mph	Days since >0.25 in. rain	Atmos mois-ture
		Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP			
1977	7/6[b]	1.54	2.71	c	1.01	1.30	.13	.09	.16	.27	2.30	-	.02	.02	-	-	.04	-	c	c	78	8.5	56	33
	7/18[b]	2.32	4.08	c	.71	1.40	.17	.10	.21	.38	3.46	-	.05	.02	-	-	-	-	c	c	98	9.5	68	36
	8/11	2.77	3.80	c	3.96	2.42	.14	.12	.21	.38	4.03	-	.07	.12	-	-	-	-	6.74	c	143	7.1	91	24
	8/29	4.06	5.13	c	2.19	3.01	.36	.12	.32	.44	7.26	-	.15	.05	-	.17	1.58	-	3.09	-	73	7.2	109	27
	9/4	2.61	4.05	c	2.96	2.01	.17	.14	.26	.38	3.81	-	.07	.12	-	-	-	-	5.00	-	111	4.9	115	26
	9/28	3.33	4.83	c	2.52	2.33	.23	.14	.28	.37	5.06	-	.07	.16	-	-	-	-	4.40	-	125	8.3	138	18
	10/10	4.13	5.46	c	4.16	3.01	.32	.10	.30	.53	6.80	-	.15	.15	-	.61	2.50	.02	4.62	-	186	4.3	152	22
	10/22	3.63	4.60	c	5.78	3.23	.25	.09	.28	.42	5.80	-	.14	.14	-	.23	2.06	-	9.14	-	203	3.0	164	16
	10/28	4.48	5.92	c	2.49	4.05	.52	.12	.33	.45	9.31	-	.12	.12	-	.40	1.66	.02	2.51	-	218	5.9	170	17
	11/27	.83	1.30	c	2.60	.72	.07	.07	.20	.16	1.30	-	-	.09	-	.09	2.42	-	5.00	-	171	2.2	22	8
	12/9	1.88	2.53	c	5.58	1.52	.11	.09	.22	.27	2.87	-	.04	.02	-	.25	1.65	-	6.75	-	159	3.2	34	4
	12/27	.46	.75	c	.77	.02	-	.04	.02	.02	.18	-	-	.07	-	.04	.66	-	1.30	-	30	6.2	0	4
1978	1/8	.47	.04	c	2.04	.43	.04	.02	.02	.02	.56	-	-	.16	-	.07	.63	-	3.20	-	51	7.6	4	7
	2/7	.36	.36	c	1.30	.09	-	.07	.16	.16	.32	-	-	.07	-	.18	.82	-	1.21	-	33	10.2	0	6
	2/25	.62	.58	c	2.75	.28	.02	-	.07	.14	.58	-	-	.14	-	.16	.65	-	7.43	-	76	5.2	13	6
	3/3	.28	.37	c	1.11	.12	-	.02	.02	-	.14	-	-	.05	-	.09	.55	.18	3.20	-	26	10.2	0	9
	3/15	1.02	1.37	c	1.99	.31	.05	.07	.12	.21	1.16	-	.02	.14	-	.07	.50	-	2.80	-	73	4.5	5	10
	3/27	.64	.62	c	1.92	.43	-	.05	.12	.12	.90	-	.05	-	.07	-	.73	-	-	-	72	6.0	8	9
	4/14	.51	.63	c	1.58	.21	.02	.07	.16	.14	.82	-	-	-	-	-	.12	1.05	3.66	-	52	9.8	9	16
	4/20	.30	.93	c	.75	-	.02	.02	.12	.09	.42	-	-	.05	-	-	.02	.05	1.61	-	30	8.1	6	13
	5/2	.86	1.16	c	4.05	.47	.07	.07	.12	.23	1.23	-	.02	.07	-	-	.04	-	5.15	-	74	6.2	8	15
	5/14	1.37	2.18	c	1.52	1.02	.07	.07	.24	.31	2.46	-	.09	.07	-	-	-	-	2.92	-	98	7.9	20	26
	6/13	2.70	3.77	c	1.82	2.20	.24	.07	.26	.38	4.79	-	.09	.14	-	-	-	-	5.12	-	111	9.6	50	25
	6/19	2.35	3.91	c	2.59	1.86	.23	.12	.19	.40	4.40	-	.09	-	-	-	.07	-	5.33	-	128	7.6	56	28
	mean	1.80	2.47	c	2.57	1.35	.14	.08	.18	.26	2.92	.12	.06	.09	.01	.11	.85	.07	4.10		102.0	6.6	53.4	15.3
	std dev	1.44	1.96	c	1.39	1.25	.14	.04	.10	.16	2.69	.00	.05	.05	c	.15	1.02	.22	2.22	.00	58.5	2.3	60.5	8.2

[a] Blank filter elemental concentrations not available; sulfate and BSO blank concentrations provided by the Fresno County APCD.

[b] Fresno APCD blank filter concentrations not available; data not included in mean.

[c] No analysis performed.

- = minimum detectable concentrations

TABLE C-7. VARIABLE CONCENTRATIONS MEASURED AT FIVE POINTS

Date		Variable concentration, ug/m^3																			Avg wind spd, mph	Days since ·0.25 in. rain	Atmos mois- ture
		Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP			
1977	7/6	1.28	1.52	.57	1.96	1.29	.06	.02	.15	.37	2.58	-	.07	.07	-	-	-	.02	1.8		125	8.5	56	33
	7/18	2.06	2.38	.81	1.55	2.20	.11	.02	.23	.42	4.46	-	.12	.09	-	-	-	-	2.8		148	9.5	68	36
	8/11	2.78	2.95	.78	3.69	3.09	.20	.02	.20	.45	6.38	-	.18	.13	-	-	-	.40	9.0		203	7.1	91	24
	8/23	3.07	3.17	.88	4.07	4.97	.25	.02	.21	.51	7.69	-	.14	.09	-	-	-	.05	5.3		220	8.2	104	28
	9/4	1.06	.93	.62	2.69	1.52	.09	-	.20	.35	2.67	-	.02	.66	-	.02	-	.02	3.7		83	4.9	115	26
	9/28	1.50	1.90	.47	1.30	1.41	.11	-	.19	.41	3.50	-	.06	.08	-	-	-	-	3.2		125	8.3	138	18
	10/10	2.53	2.71	.68	2.75	3.01	1.32	.02	.31	.51	5.95	-	.15	.13	-	-	-	-	4.1		158	4.3	152	22
	10/22	2.75	2.80	.60	5.60	3.83	.22	.02	.22	.46	6.43	-	.18	.11	-	-	-	.09	7.7		194	3.0	164	16
	11/9	1.55	1.82	.81	4.05	2.67	.11	-	.21	.38	3.99	-	.19	.25	-	-	-	-	5.2		148	2.2	5	13
	11/27	.47	.36	.34	2.25	.81	.04	-	.13	.17	1.19	-	-	.13	-	-	-	-	3.8		82	2.2	22	8
	12/9	.87	.56	.49	6.24	1.43	.07	-	.22	.31	3.04	-	.11	.16	-	-	-	.02	15.5		30	3.2	34	4
	12/27	.11	-	.37	.97	-	-	-	-	.02	.33	-	-	.07	-	-	-	-	4.5		141	6.2	0	4
1978	1/2	.02	-	.09	2.55	.02	-	-	-	.04	.16	-	-	.02	-	-	-	.02	13.5		67	7.8	5	4
	1/26	.09	-	.22	1.25	-	.02	-	.02	.11	.31	-	-	.13	-	-	-	-	5.5		58	4.8	8	5
	2/7	.29	-	.50	1.28	.09	.02	-	.11	.22	1.19	-	-	.02	-	-	-	.86	5.0		47	10.2	0	6
	3/3	.80	-	.17	.70	-	-	-	.04	.06	.32	-	-	-	-	-	-	2.10	6.4		19	10.2	0	9
	3/15[a]	.36	.38	.21	.81	.11	-	-	.04	.11	.91	-	-	.08	-	-	-	-	3.0			4.5	5	10
	3/27	.28	.04	.32	1.63	.49	.06	-	.06	.15	1.00	-	-	.06	-	-	-	-	5.1		81	6.0	8	9
	4/14	1.12	1.46	.28	.89	.93	.08	.02	.14	.30	2.71	-	.04	.06	-	-	-	.55	2.5		151	9.8	9	16
	4/20	.27	.47	.12	.45	-	-	-	.10	.15	.92	-	-	.07	-	-	-	-	3.0		79	8.1	6	13
	5/2	.63	.44	.28	2.77	1.12	.05	.02	.09	.30	1.70	-	.02	.14	-	-	-	-	4.9		103	6.2	8	15
	5/14	.70	.88	.25	.65	.61	.07	.02	.16	.29	.90	-	.05	-	-	-	-	-	4.5		103	7.9	20	26
	6/7	1.99	2.20	.64	.19	2.57	.14	.02	.05	.32	4.20	-	.07	.05	-	-	-	.07	5.3		138	8.6	44	40
	6/19	2.18	2.48	.76	2.11	3.74	.18	.05	.21	.48	5.52	-	.18	.02	-	-	-	-	.7		196	7.6	56	28
	mean	1.20	1.23	.47	2.18	1.58	.14	.02	.14	.31	2.84	-	.07	.11	-	-	-	.18	5.3		112.5	6.6	46.6	17.2
	std dev	.96	1.11	.24	1.59	1.46	.26	.01	.08	.16	2.28		.07	.13	-	-	-	.46	3.4		60.0	2.5	53.0	10.8

[a] TSP concentrations not available.

- = minimum detectable concentrations

TABLE C-8. VARIABLE CONCENTRATIONS MEASURED AT MERCED

Date		Variable concentration, ug/m^3																			Avg wind spd, mph	Days since >0.25 in. rain	Atmos mois-ture
		Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP			
1977	7/18[a]	2.33	4.46	.53	2.00	2.74	.44	.11	.42	.44	5.77	-	.11	.11	-	-	.09	-	b	b	93	11.8	78	28
	7/30	2.27	4.54	.65	2.66	3.38	.30	.09	.26	.43	6.15	-	.13	.15	-	.04	.80	-	1.12	-	33	8.3	90	37
	8/11	1.85	3.25	.60	4.20	2.48	.19	.13	.30	.39	4.61	-	.06	-	-	.15	.28	-	6.85	-	104	10.8	101	23
	8/23	2.09	3.69	.62	4.20	2.98	.33	.09	.38	.44	5.54	.22	.07	.18	-	-	.80	-	6.24	-	122	10.5	113	29
	9/4	1.80	3.26	.47	3.71	2.18	.23	.11	.30	.30	4.11	-	.08	.08	-	.02	-	-	3.31	-	74	7.2	125	25
	9/28	-	-	-	.02	.09	.02	.06	.13	.06	.06	-	-	-	.09	-	-	-	5.27	.08	53	8.2	10	13
	10/10	2.87	4.64	.58	4.13	3.38	.40	.09	.38	.40	5.96	-	.13	.20	-	.511	.18	-	2.62	-	141	4.8	22	22
	10/22	2.88	4.30	.78	6.96	4.04	.40	.11	.44	.44	7.16	-	.20	.24	-	.16	.71	-	7.15	-	141	3.9	34	15
	11/9	1.85	2.47	.75	7.91	2.72	.25	.16	.41	.44	5.04	-	.13	.38	-	.443	.22	-	8.24	-	155	4.5	5	11
	11/27	.47	-	.45	3.64	.72	.06	.02	.21	.19	1.66	-	.02	.19	-	.171	.98	-	1.34	-	102	7.2	8	9
	12/9	.60	-	.43	5.32	1.11	.11	.06	.32	.32	2.19	-	.06	.17	-	.281	.38	-	5.77	-	105	4.6	19	4
	12/27	.02	-	.25	.88	.34	.05	.07	.18	.20	.52	-	-	.07	-	-	-	-	3.94	-	22	5.2	5	1
1978	1/8	.02	-	.25	1.49	.29	.06	.04	.13	.06	.42	-	-	.15	-	-	-	-	2.52	-	39	11.5	0	3
	1/26	.42	-	.26	3.80	.83	.10	.06	.26	.22	1.54	-	.02	.12	-	-	.40	-	2.94	-	105	5.5	12	4
	2/7	.16	-	.33	1.22	.07	.09	.02	.13	.16	.49	-	-	.07	-	-	-	.40	1.75	-	20	15.0	0	5
	3/9	.11	-	.21	1.50	.32	-	.04	.11	.11	.69	-	-	.04	-	.02	.40	-	2.79	-	35	5.5	6	4
	3/15	.36	.34	.36	1.84	.76	.06	.51	.23	.23	1.80	-	.06	.11	-	.08	-	-	4.74	-	63	3.3	5	8
	3/27	.51	.32	.34	3.00	.90	.06	.09	.32	.24	1.97	-	.06	.06	-	.02	.64	-	3.35	-	86	8.3	7	8
	4/8	.36	-	.29	3.04	.61	.10	.04	.19	.15	1.24	-	-	.04	-	-	.40	-	1.90	-	56	11.9	3	15
	4/14	.36	-	.25	2.22	.55	.08	.06	.21	.21	1.27	-	-	-	-	-	-	1.55	2.56	-	50	8.6	9	10
	4/20	.32	.04	.30	1.26	.43	.09	.04	.17	.21	1.36	-	-	.09	-	.11	-	.06	2.10	-	39	10.5	15	11
	5/14	.78	1.17	.39	1.91	1.30	.13	.09	.19	.26	2.34	-	.06	.06	-	-	.04	-	2.36	-	65	11.7	20	20
	6/7	1.38	2.72	.42	2.36	2.10	.25	.11	.38	.40	3.52	-	.02	-	-	-	-	-	3.22	-	99	13.0	43	30
	6/19	1.23	1.79	.36	3.00	2.13	.23	.11	.36	.36	3.40	-	.09	.02	-	-	.68	-	4.24	-	82	7.3	55	25
	mean	.99	1.42	.40	3.06	1.47	.16	.10	.26	.27	2.74	.12	.06	.11	.01	.09	.57	.10	3.75		77.9	8.1	30.7	15.5
	std dev	.94	1.75	.19	1.89	1.22	.12	.10	.10	.12	2.12	b	.05	.09	b	.14	.78	.33	1.98	b	39.7	3.2	38.7	12.8

[a] Hi vol flow rate not available; 1850 u^3 assumed, data not included in mean and std dev.

[b] No analysis performed.

- = minimum detectable concentrations

TABLE C-9. VARIABLE CONCENTRATIONS MEASURED AT MODESTO (J ST)

Date		Variable concentration, ug/m^3																				Avg wind spd, mph	Days since ·0.25 in. rain	Atmos mois- ture
		Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP			
1977	7/6	.50	.57	.94	2.38	1.37	.16	.07	.32	.34	2.52	-	.14	.18	-	-	-	-	3.81	-	93	8.6	65	30
	7/18	1.10	2.05	.16	2.20	1.61	.20	.09	.25	.31	3.59	-	.04	.13	.04	-	-	-	7.01	-	162	11.8	77	28
	8/11	1.60	2.55	.50	4.48	2.28	.34	.07	.20	.25	3.83	-	.14	-	-	.09	.11	-	9.82	-	122	10.8	96	23
	8/23	.65	1.95	.22	1.25	1.05	.11	.04	.13	.18	2.15	-	.02	.07	-	-	-	-	4.38	-	91	10.5	107	26
	9/4	.59	.93	.66	3.52	.88	.11	.05	.16	.18	1.94	-	-	.05	-	.09	-	-	4.60	-	75	7.2	119	25
	9/28[a]	.81	2.08	b	2.60	1.38	.11	.09	.25	.36	2.67	-	.04	.07	-	-	.43	.02	b	b	76			
	10/11	2.32	4.54	.47	4.42	3.25	.35	.14	.28	.40	5.76	-	.14	.21	-	-	1.26	-	3.74	-	162	4.8	21	17
	10/22	2.01	4.00	.39	6.10	3.27	.37	.09	.23	.37	5.39	-	.14	.27	-	.23	1.99	.02	7.65	-	210	3.9	33	15
	11/9	1.52	2.32	1.17	8.29	2.93	.30	.11	.28	.33	4.84	-	.17	.35	-	.41	4.27	.07	7.75	.10	284	4.5	4	11
	11/27	.11	.06	.24	.56	.06	.09	.09	.17	.09	.65	-	-	.06	-	-	-	.02	4.35	-	47	7.2	6	9
	12/9	.48	-	.24	5.04	1.99	.13	.11	.19	.19	2.10	-	.09	.09	-	.24	2.05	.02	6.98	-	171	4.6	18	4
	12/15[c]	.51	.04	.15	3.04	.61	.08	.04	.11	.02	.84	-	-	.04	-	-	.87	7.97	b	b	85			
1978	1/8	.02	-	.18	2.07	.31	.02	.04	.02	-	.59	-	-	.05	-	-	.05	-	5.19	-	54	11.5	0	3
	1/26	.49	.58	.26	3.65	.85	.30	.12	.16	.18	2.10	-	-	.07	-	.07	.95	-	4.60	-	145	5.5	10	4
	2/7	.12	.07	.33	1.13	.22	.02	.05	.09	.09	.76	-	-	.07	-	.19	.53	.82	.26	-	45	15.0	0	5
	3/9	.07	.19	.28	1.78	.23	.09	.09	.10	.10	.78	-	-	.03	-	-	.71	-	2.37	.02	39	5.5	5	4
	3/15	.54	.30	.21	2.90	.87	.07	.07	.17	.14	.16	-	.07	.19	-	-	.77	-	3.69	-	79	3.3	4	8
	3/21	.07	-	.16	2.63	.37	.09	.10	.09	.12	.92	-	-	.07	-	.02	.07	-	3.40	-	55	8.2	0	7
	4/2	.16	-	.20	2.13	.05	.05	.05	.02	.04	.43	-	-	.09	-	-	.05	.34	3.03	-	37	8.3	2	9
	4/20	.13	.01	.18	1.37	.30	.09	.07	.15	.12	.74	-	-	.06	-	-	.28	.21	2.28	-	37	10.5	14	11
	5/2	.74	.38	.28	3.57	1.11	.13	.09	.19	.18	2.13	-	.03	.13	-	-	-	-	2.74	-	70	7.6	7	16
	5/14	1.03	1.78	.31	3.01	1.50	.28	.07	.21	.21	3.32	-	.06	.07	-	-	.24	-	3.32	-	134	11.7	26	20
	6/7	.99	1.58	.29	1.52	1.61	.20	.11	.17	.25	2.86	-	.09	.08	-	-	-	.02	4.13	.02	88	13.0	43	0
	6/19	.82	.93	.14	2.42	1.32	.14	.09	.19	.23	2.49	-	.07	.01	-	-	-	-	4.97	-	78	b	55	b
	mean	1.18	1.17	.32	3.00	1.25	.17	.08	.17	.20	2.28	.12	.06	.10	.01	.07	.61	.08	4.55		103.5	7.9	32.4	12.5
	std dev	2.29	1.31	.23	1.81	1.00	.11	.03	.08	.11	1.64	.00	.06	.09	.01	.11	1.03	.18	2.17		64.2	3.7	37.7	9.4

[a] Blank filter concentrations not available; data not used in computing means.

[b] No analysis performed.

[c] Insufficient filter material for chemical analysis; data not used in computing means.

- = minimum detectable concentrations

TABLE C-10. VARIABLE CONCENTRATIONS MEASURED AT WOODLAND

Date		Variable concentration, ug/m^3																			Avg wind spd, mph	Days since 0.25 in. rain	Atmos mois-ture
		Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP			
1977	7/6	1.81	1.20	.31	.35	1.70	.22	.07	.26	.39	3.67	-	.09	.28	-	-	-	.85	4.59		82	6.7	66	27
	7/18	1.61	3.62	.38	1.92	1.87	.22	.13	.31	.40	4.64	-	.09	.20	-	-	-	.20	.49		92	11.7	78	20
	8/11	2.23	1.68	.08	1.83	1.55	.09	-	.18	.40	4.46	-	.04	.20	-	-	-	.09	4.61		96	6.9	102	20
	8/23	3.16	2.37	.01	1.66	2.24	.13	-	.20	.40	6.38	-	.09	.36	-	-	-	.36	2.91		145	11.9	114	21
	9/4	1.48	2.80	.39	1.97	1.54	.24	.06	.32	.36	4.04	-	.13	.34	-	-	-	-	5.37		76	5.8	126	23
	9/28	.56	.46	.29	1.15	.62	.08	.08	.17	.25	1.92	-	.02	.21	-	-	-	.02	4.77		32	7.9	10	8
	10/10	2.46	4.43	.44	1.67	2.52	.40	.13	.32	.47	6.95	-	.15	.23	-	-	.06	-	1.81		131	3.9	22	18
	10/22	2.55	4.70	.41	3.19	2.65	.41	.10	.35	.39	6.75	-	.17	.19	-	-	.56	-	2.50		150	2.5	34	16
	11/9	.99	1.57	.33	2.31	1.98	.12	.10	.31	.33	3.13	-	.02	.14	-	.19	.49	-	.56		105	2.3	5	13
	11/27	.61	.29	.35	.57	.12	-	.02	.04	.08	.96	-	-	.14	-	-	-	.06	-		57	1.7	7	6
	12/9	.26	-	.31	2.32	.45	.06	.04	.21	.19	1.41	-	-	-	-	.26	-	-	1.84		80	1.7	19	3
	12/27	.19	.21	.39	.19	-	-	-	-	.02	-	-	-	-	-	-	.08	-	-		17	6.9	6	0
1978	1/8	.08	-	.25	1.89	.23	.04	.02	.06	.11	.51	-	-	.15	-	-	-	-	3.92		55	6.2	0	3
	1/26	.50	-	.28	1.64	.67	.15	.09	.26	.28	2.01	-	.02	.15	-	.06	1.02	-	1.02		102	2.6	9	5
	2/7	.04	-	.28	.26	.26	-	.04	.09	.04	.51	-	-	.09	-	-	-	1.57	.92		25	16.4	0	7
	3/3	.13	.15	.33	.43	-	-	-	-	-	-	-	-	-	-	-	-	.39	2.48		21	16.0	1	8
	3/15	.54	-	.31	.94	.38	.09	.09	.29	.31	1.79	-	.04	-	-	.02	-	-	1.73		52	4.2	8	11
	3/27[a]	.68	.38	.79	.97	.14	-	-	.07	.11	1.76	-	.09	.11	-	-	.23	.29			58	6.5	19	7
	4/14	.89	.89	.54	2.01	.36	.04	-	.20	.29	2.21	-	.02	-	-	-	-	1.88	10.13		74	8.3	9	9
	4/20	.25	-	.92	.04	-	-	-	.07	.04	.31	-	-	.02	-	-	-	.09	-		24	11.1	6	11
	5/2	.68	.57	.34	.38	.86	.05	.09	.27	.29	2.24	-	-	.07	-	-	-	-	3.18		54	3.2	8	16
	5/14	.52	1.01	.38	.43	.47	.13	.09	.25	.29	2.00	-	.02	.02	-	-	.11	.11	.97		56	13.7	20	17
	6/7[b]	1.09	2.41		.74	1.18	.16	.12	.35	.35	3.43	-	.09	.07	-	-	-	-			103	7.8	44	28
	6/19[b]	.93	1.52		1.25	1.07	.18	.09	.30	.34	2.91	-	.09	.09	-	-	-	.09			76	8.2	56	20
	mean	1.00	1.24	.44	1.29	.98	.12	.06	.20	.25	2.66	.12	.05	.14	-	.03	.12	.27	2.56		73	7.2	31	12
	std dev	.92	1.50	.24	.89	.89	.12	.04	.11	.15	2.18	.00	.05	.11	-	.07	.26	.53	2.43		40	4.6	40	7

[a] Insufficient filter material for chemical analyses; data not used in computing means.

[b] Blank filters not available; data not used in computing means.

- = minimum detectable concentrations

TABLE C-11. VARIABLE CONCENTRATIONS MEASURED AT LIVE OAK

Date		Variable concentration, ug/m^3																			Avg wind spd, mph	Days since 0.25 in. rain	Atmos mois-ture
		Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP			
1977	7/6	1.18	2.88	.04	1.77	1.44	.27	.11	.27	.33	3.95	-	.07	.13	.04	-	-	-	5.62	-	118	6.2	66	27
	7/18	1.48	3.39	.07	1.57	1.84	.27	.13	.31	.34	4.21	-	.09	.18	.04	.18	-	-	7.18	-	112	11.7	78	20
	7/24	1.39	2.76	.34	2.06	1.52	.27	.11	.31	.36	3.92	.22	.07	.04	-	.20	-	-	6.02	-	87	14.0	84	14
	8/11	3.52	2.88	.35	2.07	2.00	.20	.07	.24	.42	6.52	-	.09	.18	.02	-	.40	.02	3.36	.25	147	6.9	102	20
	8/23	2.33	2.44	.38	.82	1.42	.13	-	.22	.44	4.90	-	.13	.11	-	-	-	-	9.93	.17	109	11.9	114	21
	9/4	2.81	5.14	.51	1.60	2.25	.45	.13	.38	.42	6.35	-	.16	.27	-	.11	-	-	2.74	-	126	5.8	126	23
	9/22	.90	1.75	.42	.65	1.08	.07	.09	.32	.37	2.70	.25	.02	.25	-	-	-	-	.05	-	56	3.5	4	18
	9/28	.76	1.40	.37	1.38	.48	.11	.11	.30	.32	2.50	-	-	.02	-	-	.18	-	2.98	-	36	7.9	10	8
	10/10	1.28	3.27	.44	.74	1.23	.20	.10	.39	.42	3.69	-	.12	.20	-	-	-	-	3.19	-	84	3.9	22	18
	10/22	1.21	2.61	.34	.75	2.22	.14	.11	.30	.32	2.90	-	.05	.18	-	-	-	-	1.31	-	63	2.5	34	16
	11/3	.82	1.87	.35	1.04	1.34	.11	.11	.26	.37	2.64	.24	.04	.07	-	-	-	.02	.37	-	94	9.8	46	8
	11/9	1.18	2.57	.42	1.86	1.77	.20	.04	.24	.38	2.97	-	.02	.16	-	-	.11	-	.31	-	97	2.3	5	13
	11/27	.70	.86	.04	1.03	.68	-	-	.07	.09	1.15	-	-	.07	-	-	.07	-	-	-	54	1.7	7	6
	12/9	.84	2.01	.38	.84	1.08	.17	.04	.36	.30	2.58	-	.04	.19	-	-	.36	-	.90	-	115	1.7	19	3
	12/30	.69	.67	.29	.90	-	-	.02	.10	.13	1.09	-	-	.08	-	-	.06	-	-	-	45	6.9	9	3
1978	2/1	.23	.47	.32	.62	.32	.06	.04	.11	.13	1.00	-	-	.15	-	-	-	-	-	-	30	10.2	13	7
	3/21	.74	.88	.33	.81	-	-	-	.07	.05	.81	-	-	.17	-	-	.64	-	3.71	.04	53	7.6	14	7
	3/27	1.50	2.06	.86	.59	.25	.02	.02	.22	.22	2.41	-	.02	.32	-	-	-	-	4.39	.18	83	6.5	20	7
	4/8[a]																							
	4/20[a]																							
	5/2	.79	1.38	.36	.72	1.10	.21	.10	.36	.36	2.41	.24	.07	.19	-	-	-	-	1.87	-	65	3.2	8	16
	5/10	1.80	3.97	.47	1.03	1.38	.39	.12	.34	.42	4.75	-	.07	.20	-	-	-	-	1.87	-	122	11.4	16	14
	5/14	1.37	2.76	.40	.91	1.21	.33	.15	.46	.46	3.72	-	.08	.13	-	-	-	-	3.58	-	91	13.7	20	17
	6/7	1.99	4.51	.45	1.31	1.94	.37	.13	.37	.47	4.93	-	.03	.13	-	-	-	-	2.29	-	119	7.8	44	28
	mean	1.34	2.39	.36	1.14	1.21	.18	.08	.27	.32	3.28	.11	.06	.16	.01	.03	.09	.01	2.81	b	85.7	7.1	39.1	14.3
	std dev	.77	1.22	.17	.48	.68	.13	.05	.11	.12	1.60	b	.04	b	.01	.06	.17	b	2.41	b	32.6	3.9	38.3	7.4

[a] Filters not analyzed.

[b] No analysis performed.

- = minimum detectable concentrations

TABLE C-12. VARIABLE CONCENTRATIONS MEASURED AT CHICO

Date		Variable concentration, ug/m^3																			Avg wind spd, mph	Days since 0.25 in. rain	Atmos moisture
		Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP		
1977	7/6	1.24	1.86	-	1.67	1.22	.23	.11	.27	.36	3.16	-	.08	.15	-	-	-	-	4.12	-	68	8.9	28	38
	7/18	.94	3.80	.37	1.68	.94	.15	.07	.31	.28	3.65	-	.02	.04	-	-	-	-	3.15	-	99	11.9	40	33
	7/24	.48	1.46	1.18	3.69	.61	.11	.04	.24	.26	2.12	-	-	-	-	-	-	-	7.80	-	73	11.4	46	20
	8/11	2.10	3.71	.60	3.07	1.39	.22	.07	.24	.40	4.66	-	.07	.02	-	.02	-	-	1.05	-	123	8.8	64	28
	8/17	3.06	5.73	.44	2.50	1.53	.35	.07	.31	.39	6.52	-	.09	-	-	-	.61	-	4.67	-	155	6.2	70	26
	9/4	1.73	4.44	.67	2.65	.98	.19	.04	.27	.33	4.56	-	.02	.15	-	.02	.25	-	4.10	-	83	5.3	88	35
	9/16	1.16	3.61	.30	1.46	.81	.18	.02	.26	.24	3.98	-	.08	.06	-	.08	.06	-	6.40	-	97	14.1	0	6
	9/22	.81	3.70	.87	1.68	.23	.14	.02	.21	.31	3.06	-	.10	.08	-	.14	.58	-	.32	-	67	9.5	4	31
	10/4	1.88	3.36	.17	3.11	.79	.27	.04	.23	.31	4.61	-	.04	.10	-	.38	1.25	-	2.87	-	106	5.3	7	21
	10/10	1.86	3.38	.28	1.75	.49	.19	.04	.25	.27	3.84	-	.04	.11	-	-	.93	-	.17	-	83	12.1	13	35
	10/28	1.10	1.73	.17	1.96	.99	.17	.08	.25	.36	3.04	-	.08	.02	-	.02	-	-	-	-	57	7.1	31	8
	11/3	1.35	6.92	.95	3.64	1.86	.22	.15	.51	.47	5.58	-	.11	.04	-	.26	.84	-	.55	-	94	7.5	38	9
	11/9	.71	3.40	.95	3.72	1.18	.08	.06	.23	.25	2.77	-	.04	.04	-	.59	2.52	.06	-	-	105	5.5	6	18
	11/27	.35	1.01	.74	2.67	.53	.02	.09	.07	.07	.99	-	-	.07	-	.50	1.29	.07	-	-	102	4.9	7	10
	12/9	.74	.66	.30	3.04	.95	.13	.08	.17	.27	2.30	-	-	.11	-	.68	2.09	.04	-	-	107	3.9	19	14
	12/27	.20	.13	.35	.13	.13	-	.02	.02	-	.09	-	-	.31	-	.02	-	-	8.15	-	26	4.0	2	2
1978	1/8	.02	-	.33	.47	-	.04	.04	.16	.11	.51	-	-	.04	-	-	.27	-	-	-	28	7.2	0	3
	1/26	1.21	2.00	.37	3.05	.79	.20	.09	.29	.31	3.18	-	.07	.07	-	.53	1.56	.02	-	-	114	4.6	10	10
	2/1	.09	-	.22	.68	-	.02	.09	.09	.09	.61	-	-	.07	-	.11	-	-	-	-	28	9.5	16	4
	2/7	.33	-	.26	.31	.13	.04	.04	.07	-	.59	-	-	-	-	-	-	.24	-	-	23	17.4	0	7
	2/13	.33	.11	.27	1.37	.18	.09	.09	.29	.22	1.28	.22	-	.02	-	.18	.44	.13	-	-	51	5.2	2	5
	3/3	.37	.24	.48	.20	.09	.02	-	-	-	.46	-	-	.02	-	-	-	-	1.39	-	31	15.0	0	8
	3/15	.69	1.65	.26	1.40	.29	.13	.13	.26	.29	2.44	-	.04	.07	-	-	.50	-	-	-	72	5.6	5	17
	3/27	.95	1.42	.44	1.02	.66	.11	.13	.22	.26	2.53	-	-	.04	-	-	-	-	.25	-	79	5.0	8	12
	mean	.99	2.26	.46	1.96	.70	.14	.07	.22	.25	2.77	.12	.04	.07	.01	.15	.55	.03	1.90		78.0	8.2	21.0	16.7
	std dev	.74	1.93	.29	1.15	.51	.09	.04	.11	.13	1.73	.04	.03	.07	.00	.22	.72	.05	2.63	.00	34.7	3.8	24.8	11.6

- = minimum detectable concentrations

TABLE C-13. VARIABLE CONCENTRATIONS MEASURED AT FORT BRAGG

Date	Variable concentration, ug/m^3																					Avg wind spd, mph	Days since >0.25 in. rain	Atmos moisture
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^{=a}$	BSO^a	NO_3^{-a}	TSP			
1977 7/18	.51	.36	.27	1.04	.09	-	-	-	.02	.32	-	-	-	-	.07	.19	.24	3.8	2.0	.8	64			
8/11	.48	.05	.58	.46	-	-	.38	-	.02	.29	-	-	.05	-	-	-	-	1.9	1.0	.4	41			
8/17	.53	.51	.37	.95	.05	-	-	-	-	.19	-	-	.09	-	-	-	-				50			
9/10	.39	.41	.22	.46	.02	-	-	-	-	.12	-	-	.12	-	-	-	2.18	3.6	4.4	.8	70			
9/28	.17	.17	.34	.22	-	-	-	-	-	-	-	-	.19	-	-	-	-	1.5	2.3	.2	28			
10/10[b]																								
10/16	.27	.10	.37	.39	.15	-	-	-	.02	-	-	-	.05	-	-	-	6.39	4.0	2.0	.3	82			
11/3[b]																								
11/9[b]																								
11/27	.35	-	.48	.75	.11	-	-	.02	.09	-	-	-	.02	-	-	-	2.90	2.1	3.1	.2	43			
12/3[b]																								
1978 1/2	.20	-	.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	1.7	.2	17			
1/26	1.01	.30	1.01	.50	-	-	-	-	-	.18	-	-	-	-	-	-	1.44	2.4	2.4	.3	63			
2/1	.52	.05	.17	.72	.27	-	-	-	.02	.37	-	-	-	-	-	-	9.36	2.9	1.9	.4	71			
2/25	.69	.57	.69	.47	.17	.05	-	-	-	.38	-	-	.05	-	-	-	2.68	2.0	1.5	.2	50			
3/3	.24	.12	.45	.05	-	-	-	-	-	-	-	-	.12	-	-	-	1.52				31			
3/9	.64	.24	.90	1.52	1.26	.02	-	-	.12	1.40	-	.09	.02	-	-	-	7.85				132			
3/15	1.52	1.73	.62	1.04	.95	.07	-	.05	.33	2.46	-	.02	.09	-	-	-	3.96				120			
3/21	1.64	1.94	.43	.90	.76	.07	-	.07	.26	1.97	-	-	-	-	-	-	1.30				116			
3/27	.88	.78	.66	1.00	.59	.05	-	.07	.21	1.11	-	.05	-	-	-	-	4.84				97			
6/7	.55	.43	.38	.88	.47	-	-	-	.07	.33	-	-	.14	-	-	.31	1.14	3.1	2.6	.4	100			
6/13	.31	-	.57	.95	.47	-	-	-	.02	.07	-	-	.07	-	-	.07	1.26	5.1	1.7	.5	155			
6/19	.38	.14	.59	1.04	.24	.02	-	-	.14	.26	-	-	.19	-	-	-	2.94	4.6	1.6	.7	126			
mean	.59	.42	.51	.70	.30	.02	.03	.02	.07	.45	-	.02	.07	-	.01	.04	2.63	2.93	2.17	.42	76.6			
std dev	.41	.55	.22	.39	.36	.02	.08	.02	.10	.68		.02	.06		.01	.08	2.74				39.7			

[a] Data provided by the ARB.

[b] Filters lost in transit.

TABLE C-14. VARIABLE CONCENTRATIONS MEASURED AT PASO ROBLES

Date		Variable concentration, ug/m^3																					Avg wind spd, mph	Days since >0.25 in. rain	Atmos moisture
		Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	RSO	NO_3^-	TSP			
1977	7/6	.20	1.80	4.50	1.76	.20	.06	-	.02	.13	.67	-	-	.11	-	-	.38	1.42	4.3	2.7	3.0	66			
	7/18	.18	-	.27	2.80	.14	.04	-	-	-	.79	-	-	.02	-	-	-	.02	4.8	3.7	2.9	68			
	8/5	.23	-	.21	2.31	.09	-	-	.05	.12	.93	-	-	.05	-	-	-	-	6.7	2.8	2.8	76			
	8/23	.34	-	.55	4.02	.51	.05	-	.07	.21	1.36	-	-	.02	-	.05	-	-	7.8	3.4	5.4	97			
	9/4	.55	.41	.21	2.64	.34	-	-	-	.09	.62	-	.05	.16	-	-	-	-	4.5	2.4	3.8	75			
	9/28	.48	.41	.37	1.01	.09	-	-	-	.02	.55	-	-	.02	-	-	.18	.05	2.6	2.3	1.2	59			
	10/4	.57	.11	.57	2.76	.25	-	-	-	.07	.73	-	-	.07	-	-	-	.05	5.0	5.2	3.3	90			
	10/22	.83	.56	.53	5.09	1.23	.10	.02	.12	.17	1.69	-	.25	.22	-	-	.36	.07	7.0	5.9	8.4	129			
	11/3	.68	.18	.34	4.53	.95	.06	.02	.07	.25	2.01	-	.07	.07	-	-	.05	.57	6.2	4.9	6.2	99			
	11/27	.57	.43	.34	1.70	.45	-	.02	-	.07	.52	-	-	.07	-	-	-	-	3.7	2.1	10.0	63			
	12/9	.75	.40	.55	6.28	1.33	.11	-	.09	.24	2.30	-	.04	.09	-	.02	.18	.13	9.3	12.9	11.3	164			
	12/27	.24	.19	.40	.73	-	-	-	-	-	-	-	-	.12	-	-	.45	-	1.8	2.5	0.9	19			
1978	1/8	.29	.07	.68	1.40	-	-	-	-	.09	.05	-	-	.14	-	-	1.22	.14	2.8	3.9	4.4	45			
	1/20	.54	.48	.29	2.10	.27	.02	-	-	.02	.79	-	-	.05	-	.27	.25	-	3.3	6.3	3.6	89			
	2/7	.18	-	.33	.61	-	-	-	-	-	-	-	-	.05	-	-	-	1.72	3.2	3.4	0.7	41			
	3/3	.29	.41	.34	.49	-	-	-	-	-	-	-	-	-	-	-	-	.41	2.4	3.1	0.9	27			
	3/15	.55	.36	.26	3.59	.67	.02	-	-	.10	1.17	-	.02	.02	-	-	.31	.02	5.1	6.3	8.1	107			
	3/27	.36	.19	.49	2.56	.38	-	-	-	.05	.67	-	-	-	-	-	.07	.95	5.9	4.5	5.9	87			
	4/14	.47	.20	.25	1.17	.12	.02	.02	-	.02	.27	-	-	-	-	-	-	.95	3.3	1.3	1.0	51			
	4/20	.24	.32	.32	.68	-	-	-	-	-	-	-	-	-	-	.05	-	.17	2.6	4.0	0.6	44			
	5/2	.62	.31	.65	3.72	.28	.02	-	-	.10	1.16	-	.02	.05	-	-	-	.21	5.0	5.1	4.9	102			
	5/14	.46	.33	.26	1.51	.08	-	-	-	-	.33	-	.05	-	-	.23	-	.18	2.6	2.8	1.3	51			
	6/13	.67	.55	.29	2.92	.67	.12	-	.05	.17	1.34	-	.02	.07	-	-	-	.07	5.6	2.9	3.0	92			
	6/19	.70	.49	.41	3.83	1.03	.02	-	-	.16	1.30	-	.02	.10	-	.05	-	.31	6.5	4.4	3.7	98			
	mean	.46	.34	.56	2.51	.39	.03	.01	.03	.09	.80	-	.01	.06	-	.04	.15	.31	4.67	4.12	4.05	76.6			
	std dev	.20	.36	.85	1.53	.40	.03	.00	.03	.08	.64		.05	.06		.07	.27	.47	1.93	2.31	3.01	33.0			

- = minimum detectable concentrations

APPENDIX D

INTERSPECIES CORRELATIONS FOR SPECIAL STUDY SITES

This appendix presents the correlation matrices for the chemical/elemental data from the eight Phase I and six Phase II special study sites.

TABLE D-1. INTERSPECIES CORRELATIONS AT BAKERSFIELD (FLOWER)[a]

	Correlation coefficient																						
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP	WS	DR	AM	AB
Al	1.00																							
Mg	.95	1.00																						
P																								
S	.16	.21		1.00																				
K	.98	.92		.20	1.00																			
Ti	.94	.83		.09	.95	1.00																		
V	.33	.31		.62	.35	.34	1.00																	
Cr	.79	.80		.38	.72	.69	.50	1.00																
Mn	.88	.86		.25	.88	.86	.51	.80	1.00															
Fe	.96	.87		.22	.98	.96	.41	.72	.88	1.00														
Co																								
Ni	.68	.66		.61	.67	.57	.57	.70	.71	.67		1.00												
Cu																								
Zn																								
Br	-.02	-.04		.48	.04	-.01	.03	-.17	-.03	.09		.17			1.00									
Pb	.20	.17		.68	.28	.21	.37	.06	.15	.34		.34			.87	1.00								
Cl	-.32	-.34		-.16	-.31	-.28	-.31	-.38	-.39	-.31		-.41			.3[illegible]	.10	1.00							
$SO_4^=$																								
BSO																								
TSP	.74	.71		.63	.77	.66	.54	.64	.75	.77		.80			.26	.51	-.33			1.00				
WS	-.22	-.26		-.52	-.27	-.14	-.33	-.16	-.19	-.29		-.28			-.51	-.71	.21			-.49	1.00			
DR	.40	.42		.17	.50	.50	.12	.23	.39	.45		.25			.03	.15	-.09			.35	-.09	1.00		
AM	.60	.59		-.41	.56	.59	-.17	.47	.46	.49		.14			-.53	-.47	-.24			.13	.27	.48	1.00	
AB																								

[a] Based on 24 samples.

WS = wind speed

DR = days since 0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

TABLE D-2. INTERSPECIES CORRELATIONS AT TAFT[a]

	Correlation coefficient																							
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP	WS	DR	AM	AB
Al	1.00																							
Mg	.97	1.00																						
P	.44	.32	1.00																					
S	.16	neg	.85	1.00																				
K	.95	.90	.60	.31	1.00																			
Ti	.89	.82	.39	.16	.83	1.00																		
V	.00	-.16	.66	.82	.06	-.02	1.00																	
Cr	.74	.65	.64	.39	.74	.72	.26	1.00																
Mn	.82	.75	.64	.37	.81	.74	.28	.92	1.00															
Fe	.98	.93	.54	.27	.95	.92	.10	.82	.87	1.00														
Co																								
Ni	.73	.62	.66	.48	.78	.63	.38	.71	.70			1.00												
Cu																								
Zn																								
Br	-.23	-.29	.10	.21	-.23	-.10	.12	.12	-.10	-.19		-.16			1.00									
Pb	-.32	-.39	.10	.23	-.32	-.26	.19	.05	-.22	-.28		-.06			.58	1.00								
Cl																								
$SO_4^=$	-.09	-.26	.66	.85	.07	-.02	.79	.16	.15	.03		.34			.21	.15		1.00						
BSO																								
TSP	.81	.68	.78	.63	.84	.79	.45	.79	.80	.87		.80			.00	-.07		.48		1.00				
WS																								
DR																								
AM																								
AB																								

[a] Based on 20 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

TABLE D-3. INTERSPECIES CORRELATIONS AT KERN REFUGE[a]

	Correlation coefficient																							
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP	WS	DR	AM	AB
Al	1.00																							
Mg	.95	1.00																						
P																								
S	.29	.12		1.00																				
K	.95	.90		.48	1.00																			
Ti	.73	.70		.53	.82	1.00																		
V	.46	.46		.66	.66	.64	1.00																	
Cr	.74	.66		.22	.70	.48	.29	1.00																
Mn	.43	.40		.22	.46	.28	.33	.65	1.00															
Fe	.94	.91		.46	.97	.86	.65	.70	.46	1.00														
Co																								
Ni	.60	.50		.76	.72	.84	.61	.44	.22	.74		1.00												
Cu	.31	.24		.77	.48	.58	.66	.30	.42	.50		.69	1.00											
Zn	.17	.17		.55	.33	.68	.69	-.14	.04	.39		.59	.59	1.00										
Br	.34	.41		.14	.41	.58	.31	.18	.11	.43		.52	.26	.39	1.00									
Pb	-.11	-.23		.81	.10	.19	.41	.01	-.01	.08		.46	.62	.33	-.08	1.00								
Cl																								
$SO_4^=$																								
BSO																								
TSP	.28	.15		.74	.45	.60	.59	.32	.14	.45		.73	.73	.52	.33	.63				1.00				
WS																								
DR																								
AM																								
AB																								

[a] Based on 23 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

TABLE D-4. INTERSPECIES CORRELATIONS AT VISALIA[a]

	Correlation coefficient																						
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP	WS	DR	AM	AB
Al	1.00																							
Mg	.93	1.00																						
P	.75	.74	1.00																					
S	.18	.24	.44	1.00																				
K	.93	.97	.79	.34	1.00																			
Ti	.75	.48	.50	.01	.49	1.00																		
V	.17	.24	.53	.33	.34	-.01	1.00																	
Cr	.34	.40	.39	.19	.43	.06	.01	1.00																
Mn	.85	.92	.85	.44	.92	.44	.47	.39	1.00															
Fe	.92	.98	.80	.34	.98	.47	.35	.41	.95	1.00														
Co																								
Ni	.73	.79	.50	.27	.72	.38	.02	.24	.73	.79		1.00												
Cu	.00	.04	-.09	-.07	-.03	-.02	-.00	-.09	.12	.04		.22	1.00											
Zn																								
Br	-.33	-.32	-.40	.15	-.30	-.23	-.13	-.17	-.24	-.30		-.35	.19		1.00									
Pb	-.14	-.13	-.12	.40	-.11	-.11	-.10	-.14	.02	-.09		-.09	.26		.60	1.00								
Cl	-.42	-.46	-.39	-.26	-.43	-.24	-.14	-.18	-.48	-.44		-.32	-.19		-.15	-.26	1.00							
$SO_4^=$	.09	.20	.08	.51	.25	-.17	.33	-.10	.25	.27		.14	-.17		.08	.08	-.11	1.00						
BSO																								
TSP	.80	.85	.74	.19	.84	.39	.32	.37	.87	.87		.65	.32		-.16	.10	-.49	.10		1.00				
WS	.02	-.02	-.09	-.57	-.05	.10	.02	.06	-.17	-.06		.01	-.10		-.37	-.72	.41	-.44		-.17	1.00			
DR	.72	.78	.43	.22	.78	.32	-.11	.39	.63	.74		.59	-.17		-.11	.14	-.30	.24		.60	-.23	1.00		
AM	.79	.78	.42	-.11	.73	.52	-.05	.35	.60	.70		.59	.12		-.36	-.42	-.25	.03		.59	.18	.54	1.00	
AG																								

[a] Based on 21 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

TABLE D-5. INTERSPECIES CORRELATIONS AT PARLIER[a]

	Correlation coefficient																							
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP	WS	DR	AM	AB
Al	1.00																							
Mg	.98	1.00																						
P																								
S	.30	.19		1.00																				
K	.98	.96		.33	1.00																			
Ti	.97	.93		.28	.95	1.00																		
V	.57	.51		.20	.57	.60	1.00																	
Cr	.74	.69		.57	.75	.74	.56	1.00																
Mn	.86	.85		.43	.86	.80	.65	.72	1.00															
Fe	.99	.96		.27	.98	.97	.62	.74	.87	1.00														
Co																								
Ni	.47	.44		.27	.52	.41	.29	.38	.35	.43		1.00												
Cu	.40	.37		.11	.42	.33	.41	.26	.27	.35		.84	1.00											
Zn																								
Br	.06	.02		.59	.16	-.06	.10	.26	.33	.04		.50	.33		1.00									
Pb	-.06	.01		.02	-.09	-.15	-.16	-.11	-.02	-.11		-.01	.08		.21	1.00								
Cl	-.35	-.29		-.31	-.33	-.30	-.39	-.42	-.44	-.34		-.13	-.24		-.16	-.18	1.00							
$SO_4^=$	-.01	.02		.10	.05	-.02	-.12	-.19	.04	-.04		-.11	-.10		.06	.21	-.06	1.00						
BSO																								
TSP	.74	.76		.33	.79	.64	.51	.58	.85	.76		.33	.23		.37	.04	-.41	.29		1.00				
WS	-.09	-.11		-.31	-.13	.06	.03	-.24	-.12	-.02		-.31	-.42		-.55	-.55	.47	-.10		-.25	1.00			
DR	.81	.82		.12	.82	.77	.20	.52	.54	.77		.62	.49		.04	-.11	-.19	-.08		.46	-.17	1.00		
AM	.77	.74		.08	.74	.79	.66	.46	.69	.81		.14	.15		-.21	.20	.26	-.07		.52	.21	.46	1.00	
AB																								

[a] Based on 22 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

TABLE D-6. INTERSPECIES CORRELATIONS AT FRESNO (CAL STATE)[a]

	Correlation coefficient																							
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	SO_4^-	BSO	TSP	WS	DR	AM	AB
Al	1.00																							
Mg	.99	1.00																						
P																								
S	.50	.46		1.00																				
K	.99	.97		.53	1.00																			
Ti	.95	.93		.35	.95	1.00																		
V	.79	.83		.43	.77	.71	1.00																	
Cr	.88	.89		.44	.87	.82	.82	1.00																
Mn	.93	.95		.54	.91	.85	.84	.92	1.00															
Fe	.98	.97		.43	.98	.98	.76	.88	.91	1.00														
Co																								
Ni	.92	.90		.42	.91	.86	.66	.83	.90	.92		1.00												
Cu	.37	.33		.22	.36	.31	.12	.20	.29	.31		.23	1.00											
Zn																								
Br	.53	.46		.42	.52	.56	.18	.41	.44	.54		.50	.27		1.00									
Pb	.31	.25		.57	.33	.30	.11	.32	.22	.31		.28	-.02		.73	1.00								
Cl	-.24	-.25		-.21	-.24	-.21	-.10	-.11	-.22	-.21		-.24	-.37		-.15	-.17	1.00							
$SO_4^=$	.79	.36		.79	.40	.23	.27	.30	.43	.29		.27	.34		.15	.26	-.07	1.00						
BSO																								
TSP	.76	.75		.71	.81	.72	.62	.74	.75	.75		.66	.34		.55	.56	-.24	.57		1.00				
WS	-.25	-.23		-.65	-.26	-.18	-.17	-.22	-.24	-.20		.20	-.22		-.39	-.66	.36	-.43		-.61	1.00			
DR	.95	.94		.52	.95	.88	.76	.82	.85	.92		.84	.45		.54	.29	-.19	.39		.77	-.30	1.00		
AM	.65	.71		.11	.63	.59	.67	.67	.77	.65		.72	.08		-.04	-.31	-.01	.21		.33	.18	.55	1.00	
AB																								

[a] Based on 22 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

TABLE D-7. INTERSPECIES CORRELATIONS AT FIVE POINTS[a]

	Correlation coefficient																						
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP	WS	DR	AM	AB
Al	1.00																							
Mg	.98	1.00																						
P	.84	.82	1.00																					
S	.45	.37	.47	1.00																				
K	.89	.87	.82	.56	1.00																			
Ti	.53	.52	.39	.21	.44	1.00																		
V	.56	.59	.46	.06	.56	.25	1.00																	
Cr	.74	.75	.73	.56	.71	.59	.39	1.00																
Mn	.65	.69	.55	.50	.62	.42	.45	.61	1.00															
Fe	.98	.96	.87	.55	.92	.53	.55	.78	.68	1.00														
Co																								
Ni	.87	.86	.82	.63	.82	.46	.56	.77	.65	.89		1.00												
Cu	.09	.06	.30	.34	.16	.07	-.21	.31	.11	.13		.06	1.00											
Zn																								
Br																								
Pb																								
Cl	-.08	-.22	-.21	-.22	-.26	-.13	-.14	-.22	-.32	-.20		-.19	-.21				1.00							
$SO_4^=$	-.08	-.16	-.13	.58	-.06	-.07	-.33	-.08	.23	-.03		.08	.00				.07	1.00						
BSO																								
TSP	.81	.86	.72	.30	.78	.38	.62	.56	.59	.82		.74	-.01				-.29	-.23		1.00				
WS	.01	.02	-.09	-.57	-.25	-.20	.21	-.21	.03	-.08		-.23	-.46				.46	-.24		.05	1.00			
DR	.77	.76	.60	.44	.67	.59	.27	.73	.61	.77		.58	.33				-.23	-.05		.58	-.16	1.00		
AM	.68	.72	.63	-.09	.55	.25	.58	.46	.46	.60		.45	.11				-.20	-.42		.58	.34	.48	1.00	
AB																								

[a] Based on 24 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

TABLE D-8. INTERSPECIES CORRELATIONS AT MERCED[a]

	Correlation coefficient																							
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP	WS	DR	AM	AB
Al	1.00																							
Mg	.97	1.00																						
P	.88	.82	1.00																					
S	.67	.52	.82	1.00																				
K	.99	.96	.89	.69	1.00																			
Ti	.97	.94	.84	.63	.96	1.00																		
V	.12	.13	.08	.09	.16	.07	1.00																	
Cr	.81	.73	.77	.80	.84	.82	.22	1.00																
Mn	.89	.85	.88	.71	.92	.88	.22	.90	1.00															
Fe	.99	.96	.92	.71	.99	.95	.18	.84	.92	1.00														
Co																								
Ni	.87	.80	.82	.72	.89	.83	.27	.76	.78	.89		1.00												
Cu	.47	.36	.67	.74	.48	.46	.11	.47	.44	.51		.61	1.00											
Zn																								
Br	.50	.37	.55	.65	.45	.45	.11	.49	.46	.47		.53	.70		1.00									
Pb	.37	.24	.58	.75	.39	.32	-.02	.49	.44	.41		.46	.80		.73	1.00								
Cl	-.20	-.22	-.20	-.15	-.23	-.17	-.12	-.18	-.16	-.21		-.24	-.25		-.15	-.20	1.00							
$SO_4^=$	.38	.3[illegible]	.42	.61	.42	.33	.34	.57	.47	.42		.47	.39		.37	.38	-.19	1.00						
BSO																								
TSP	.68	.54	.68	.86	.68	.65	.15	.85	.69	.68		.63	.61		.67	.66	-.24	.61		1.00				
WS	-.21	-.11	-.17	-.42	-.24	-.13	-.39	-.32	-.20	-.24		-.46	.46		-.47	-.42	.15	-.39		-.39	1.00			
DR	.63	.71	.50	.24	.63	.58	.05	.44	.60	.63		.18	-.05		-.11	-.07	-.17	.22		.21	.12	1.00		
AM	.60	.70	.41	.10	.61	.63	.07	.50	.62	.59		.10	-.14		-.06	-.06	-.14	-.00		.24	.33	.64	1.00	
AB																								

[a] Based on 23 samples.

WS = wind speed

DR = days since 0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

TABLE D-9. INTERSPECIES CORRELATIONS AT MODESTO (J ST)[a]

	Correlation coefficient																							
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP	WS	DP	AM	AB
Al	1.00																							
Mg	.37	1.00																						
P	.13	.43	1.00																					
S	.19	.54	.75	1.00																				
K	.32	.87	.52	.79	1.00																			
Ti	.46	.83	.45	.67	.85	1.00																		
V	.03	.38	.19	.44	.52	.57	1.00																	
Cr	.30	.57	.35	.51	.73	.67	.48	1.00																
Mn	.27	.82	.38	.58	.90	.81	.54	.89	1.00															
Fe	.40	.93	.51	.69	.95	.90	.51	.72	.92	1.00														
Co																								
Ni	.22	.70	.47	.67	.89	.70	.36	.74	.83	.79		1.00												
Cu	.08	.49	.55	.71	.64	.46	.40	.57	.61	.55		.62	1.00											
Zn																								
Br	.02	.22	.74	.77	.50	.33	.20	.29	.31	.40		.47	.57		1.00									
Pb	.05	.34	.73	.83	.61	.45	.46	.38	.41	.49		.56	.75		.87	1.00								
Cl	-.16	-.28	-.01	-.25	-.34	-.38	-.35	-.39	-.35	-.31		-.29	-.07		.22	-.02	1.00							
$SO_4^=$	.04	.47	.39	.63	.65	.59	.21	.44	.49	.58		.60	.26		.45	.40	-.50	1.00						
BSO																								
TSP	.31	.66	.64	.86	.86	.78	.51	.68	.75	.82		.73	.71		.71	.81	-.29	.68		1.00				
WS	.14	-.13	-.18	-.47	-.31	-.22	-.45	-.27	-.26	-.18		-.27			-.21	-.44	.43	-.24		-.31	1.00			
DR	.05	.33	.08	-.03	.24	.21	-.29	.33	.38	.31		.25			-.12	-.30	-.29	.40		.09	.14	1.00		
AM	.27	.43	.15	.10	.29	.30	-.26	.51	.47	.39		.31			-.10	-.16	-.22	.25		.21	.23	.69	1.00	
AB																								

[a] Based on 22 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

TABLE D-10. INTERSPECIES CORRELATIONS AT WOODLAND[a]

	Correlation coefficient																							
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP	WS	DR	AM	AB
Al	1.00																							
Mg	.85	1.00																						
P	.53	.18	1.00																					
S	.53	.58	.04	1.00																				
K	.89	.90	.23	.60	1.00																			
Ti	.71	.89	-.05	.55	.85	1.00																		
V	.24	.52	-.44	.27	.54	.68	1.00																	
Cr	.55	.65	-.09	.56	.74	.76	.80	1.00																
Mn	.79	.73	.20	.56	.85	.76	.61	.89	1.00															
Fe	.96	.91	.33	.60	.96	.86	.48	.73	.89	1.00														
Co																								
Ni	.80	.92	.11	.50	.84	.93	.47	.64	.70	.88		1.00												
Cu	.72	.60	.23	.36	.73	.58	.22	.40	.61	.72		.68	1.00											
Zn																								
Br	-.18	-.16	-.20	.39	.02	-.09	.09	.18	-.00	-.09		-.23	-.21		1.00									
Pb	.07	.11	-.02	.38	.23	.32	.37	.34	.18	.16		.11	.06		.25	1.00								
Cl	-.11	-.15	.01	-.14	-.17	-.22	-.30	-.16	-.12	-.13		-.13	-.13		-.19	-.22	1.00							
$SO_4^=$	.19	.07	.13	.30	.08	.04	-.22	.15	.31	.18		.13	.20		-.20	-.23	.50	1.00						
BSO																								
TSP	.86	.76	.27	.75	.88	.76	.40	.69	.80	.90		.72	.61		.17	.42	-.14	.11		1.00				
WS	-.13	-.12	.22	-.44	-.25	-.29	-.29	-.39	-.31	-.22		-.17	-.12		-.41	-.38	.45	-.02		-.39	1.00			
DR	.71	.54	.51	.32	.60	.40	-.01	.38	.60	.64		.59	.76		-.17	-.17	-.08	.27		.50	.08	1.00		
AM	.70	.65	.35	.14	.73	.60	.37	.63	.77	.73		.67	.65		-.27	-.14	.01	.23		.52	.08	.75	1.00	
AB	.15	.28	-.11	.30	.42	.16	.42	.36	.31	.23		.08	.19		.44	.14	-.06	-.23		.28	-.05	.16	.27	1.00

[a] Based on 21 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

TABLE D-11. INTERSPECIES CORRELATIONS AT LIVE OAK[a]

	Correlation coefficient																							
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP	WS	DR	AM	AB
Al	1.00																							
Mg	.72	1.00																						
P	.25	.21	1.00																					
S	.49	.45	-.29	1.00																				
K	.65	.80	-.08	.53	1.00																			
Ti	.55	.89	.05	.48	.73	1.00																		
V	.23	.64	-.05	.31	.60	.76	1.00																	
Cr	.32	.68	.27	.12	.59	.75	.80	1.00																
Mn	.60	.76	.23	.33	.76	.75	.68	.85	1.00															
Fe	.91	.87	.15	.56	.80	.79	.53	.59	.82	1.00														
Co	.24	-.18	.02	-.05	.03	-.08	.23	.18	.16	-.12	1.00													
Ni	.68	.68	.04	.26	.62	.65	.41	.53	.64	.78	-.07	1.00												
Cu																								
Zn	.15	.22	-.58	.46	.27	.22	.26	.04	.07	.27	-.17	.22		1.00										
Br	.20	.36	-.19	.52	.34	.38	.35	.19	.13	.31	.20	.37		.35	1.00									
Pb	.04	-.29	-.05	.09	-.27	.30	-.42	-.35	.38	-.17	-.23	-.24		-.05	-.19	1.00								
Cl																								
$SO_4^=$	.44	.32	-.06	.27	.21	.24	.08	.15	.30	.46	-.16	.56		.45	.44	-.05		1.00						
BSO																								
TSP	.81	.80	.08	.54	.70	.72	.31	.47	.65	.87	-.23	.64		.39	.23	.02		.42		1.00				
WS	.19	.18	.00	.19	-.00	.29	.30	.10	.22	.27	.04	.24		.15	.43	-.18		.55		.14	1.00			
DR	.77	.58	-.08	.55	.61	.47	.23	.18	.44	.77	-.06	.76		.36	.53	-.08		.65		.65	.37	1.00		
AM	.61	.75	-.10	.40	.74	.69	.59	.53	.71	.77	-.01	.62		.44	.21	-.33		.46		.62	.15	.58	1.00	
AB	-.19	-.00	-.06	-.18	.06	-.10	.14	.18	.17	-.05	.32	.12		.06	-.00	-.07		-.08		.02	-.02	-.00	-.13	1.00

[a] Based on 22 samples.

WS = wind speed

DR = days since 0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

TABLE D-12. INTERSPECIES CORRELATIONS AT CHICO[a]

	Correlation coefficient																							
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP	WS	DR	AM	AB
Al	1.00																							
Mg	.77	1.00																						
P	-.03	.37	1.00																					
S	.47	.59	.54	1.00																				
K	.71	.79	.24	.73	1.00																			
Ti	.93	.77	-.08	.54	.75	1.00																		
V	.07	-.14	-.07	.25	.40	.20	1.00																	
Cr	.55	.76	.19	.59	.72	.73	.51	1.00																
Mn	.73	.77	.15	.68	.81	.86	.44	.89	1.00															
Fe	.92	.93	.15	.62	.83	.94	.21	.79	.88	1.00														
Co																								
Ni	.59	.71	.09	.37	.63	.71	.20	.63	.72	.71		1.00												
Cu	-.08	-.12	-.22	-.19	-.14	-.10	-.19	-.27	-.18	-.15		-.12	1.00											
Zn																								
Br	-.08	.01	.19	.56	.21	-.03	.17	.03	.06	.01		-.01	.03		1.00									
Pb	.10	.17	.22	.60	.26	.11	.12	.13	.16	.16		.06	.02		.91	1.00								
Cl	-.32	-.36	-.09	-.20	-.28	-.35	-.04	-.26	-.42	-.38		-.32	-.25		.13	.07	1.00							
$SO_4^=$	.16	.15	.12	.02	.12	.18	-.40	-.02	-.01	.15		.01	.42		-.34	-.36	-.29	1.00						
BSO																								
TSP	.76	.70	.23	.76	.76	.74	.24	.56	.68	.80		.46	-.19		.41	.49	-.28	.06		1.00				
WS	-.11	-.05	-.02	-.36	-.22	-.15	-.43	-.19	-.29	-.12		-.00	-.35		-.48	-.47	.28	.11		-.32	1.00			
DR	.64	.58	.28	.48	.64	.57	.11	.45	.58	.64		.25	-.08		-.24	-.18	-.29	.31		.48	-.11	1.00		
AM	.61	.54	.11	.35	.41	.58	-.05	.37	.56	.59		.30	.09		-.18	.02	-.29	.15		.46	.06	.56	1.00	
AB	.24	.09	-.35	.11	.15	.30	-.01	.14	.29	.22		.24	.00		-.01	.04	-.19	-.16		.02	-.05	.02	.10	1.00

[a] Based on 24 samples.

WS = wind speed

DR = days since ≥0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

TABLE D-13. INTERSPECIES CORRELATIONS AT FORT BRAGG[a]

	Correlation coefficient																						
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	BSO	TSP	WS	DR	AM	AB
Al	1.00																							
Mg	.91	1.00																						
P																								
S	.42	.33		1.00																				
K	.54	.55		.74	1.00																			
Ti	.84	.90		.31	.60	1.00																		
V	-.07	-.16		-.15	-.19	-.13	1.00																	
Cr	.76	.81		.31	.52	.83	-.11	1.00																
Mn	.78	.81		.54	.74	.83	-.13	.85	1.00															
Fe	.91	.94		.41	.66	.91	-.06	.84	.91	1.00														
Co																								
Ni	.16	.07		.57	.73	.20	-.08	.22	.34	.18		1.00												
Cu	-.32	-.11		-.15	-.18	-.18	-.06	-.28	-.07	-.17		-.26	1.00											
Zn																								
Br	-.05	-.03		.21	-.14	-.13	-.06	-.11	-.13	-.05		-.08	-.22		1.00									
Pb	-.08	-.04		.23	.05	-.21	-.09	-.17	-.10	-.08		-.13	.14		.47	1.00								
Cl	.10	-.03		.37	.49	.14	-.23	.11	.23	.14		.53	-.29		-.21	-.25	1.00							
$SO_4^=$																								
BSO																								
TSP	.42	.36		.77	.77	.38	-.22	.34	.57	.45		.40	.03		-.08	.17	.37			1.00				
WS																								
DR																								
AM																								
AB																								

[a] Based on 19 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

TABLE D-14. INTERSPECIES CORRELATIONS AT PASO ROBLES[a]

	Correlation coefficient																								
	Al	Mg	P	S	K	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br	Pb	Cl	$SO_4^=$	NO_3^-	BSO	TSP	WS	DR	AM	AB
Al	1.00																								
Mg	.09	1.00																							
P																									
S	.70	.01		1.00																					
K	.80	.15		.90	1.00																				
Ti	.49	.32		.67	.71	1.00																			
V	.41	.00		.18	.35	.21	1.00																		
Cr	.48	.04		.73	.74	.80	.38	1.00																	
Mn	.56	.16		.84	.81	.71	.23	.76	1.00																
Fe	.71	.09		.96	.89	.74	.23	.77	.88	1.00															
Co																									
Ni	.47	.15		.43	.51	.45	.41	.64	.25	.34		1.00													
Cu	.36	.29		.33	.42	.36	.23	.40	.40	.25		.63	1.00												
Zn																									
Br	.07	.05		-.10	-.11	-.14	-.17	-.13	-.26	-.07		.00	-.22		1.00										
Pb	-.13	.12		-.08	-.08	.01	-.07	-.04	-.03	-.16		.12	.48		-.08	1.00									
Cl	-.34	.30		-.27	-.18	-.05	.08	-.15	-.12	-.24		-.16	-.12		-.17	-.07	1.00								
$SO_4^=$	.49	-.03		.91	.80	.63	.09	.74	.84	.88		.29	.21		-.21	-.20	-.13	1.00							
NO_3^-	.60	.06		.76	.76	.46	.36	.54	.64	.70		.34	.32		-.16	.12	-.26	.67	1.00						
BSO	.48	-.01		.72	.65	.47	-.11	.47	.47	.65		.23	.15		.10	.11	-.17	.60	.64	1.00					
TSP	.73	.09		.95	.86	.65	.12	.67	.76	.93		.40	.26		-.02	-.12	-.24	.88	.77	.77	1.00				
WS																									
DR																									
AM																									
AB																									

[a] Based on 24 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

APPENDIX E

ROTATED FACTOR MATRICES

This appendix presents the rotated factor matrices for the eight Phase I and six Phase II special study sites.

TABLE E-1. BAKERSFIELD (FLOWER) ROTATED FACTOR MATRIX[a]

Variable	Soil factor	Auto factor	Fuel oil factor	Dry soil factor	Maritime air factor	Commonality, h^2
Al	.99	.04	.10	.08	-.10	1.00
Mg	.90	.03	.15	.14	-.17	.87
S	.03	.49	.82	.12	-.05	.93
K	.95	.12	.11	.20	-.10	.98
Ti	.93	.03	.06	.21	-.03	.91
V	.26	.15	.68	-.04	-.18	.58
Cr	.73	-.15	.45	-.00	-.18	.79
Mn	.86	-.03	.33	.08	-.12	.87
Fe	.94	.16	.14	.14	-.08	.96
Ni	.59	.15	.60	.02	-.13	.75
Br	-.01	.87	.07	-.02	.39	.91
Pb	.14	.93	.26	.06	.10	.96
Cl	-.25	.13	-.24	-.00	.62	.53
TSP	.65	.35	.49	.11	-.16	.83
WS	-.13	-.73	-.16	-.02	.37	.72
DR	.34	.04	.06	.81	.01	.78
AM	.60	-.52	-.30	.39	-.15	.89
Total variation, %	50.6	20.9	9.0	4.8	4.6	89.8
Common variation, %	59.4	24.0	9.1	4.3	3.2	
Eigenvalue	8.47	3.43	1.30	.62	.46	

[a] Based on 24 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

☐ HEAVY FACTOR LOADINGS, ≥0.60

⬚ MODERATE FACTOR LOADINGS, 0.40 TO 0.59

TABLE E-2. TAFT ROTATED FACTOR MATRIX[a]

Variable	Soil factor	Fuel oil factor	Auto factor	Commonality, h^2
Al	.97	-.02	-.20	.98
Mg	.92	-.18	-.26	.95
P	.51	.75	.11	.83
S	.21	.92	.17	.92
K	.93	.14	-.23	.93
Ti	.89	-.01	-.08	.79
V	.02	.87	.08	.77
Cr	.86	.23	.23	.84
Mn	.86	.24	-.05	.80
Fe	.99	.10	-.15	1.00
Ni	.73	.40	-.09	.70
Br	-.09	.10	.73	.56
Pb	-.17	.13	.79	.67
$SO_4^=$	-.05	.92	.08	.86
TSP	.83	.50	.00	.94
Total variation, %	54.9	23.6	9.0	87.5
Common variation, %	64.7	27.0	8.3	
Eigenvalue	8.11	3.38	1.04	

[a] Based on 20 samples.

☐ HEAVY FACTOR LOADINGS, $\geq$0.60

⬚ MODERATE FACTOR LOADINGS, 0.40 TO 0.59

TABLE E-3. KERN REFUGE ROTATED FACTOR MATRIX[a]

Variable	Soil factor	Fuel oil factor	Unidentified Cr factor	Commonality, h^2
Al	.88	.18	.38	.95
Mg	.97	.05	.24	1.00
S	.04	.87	.19	.79
K	.81	.41	.36	.96
Ti	.69	.63	.05	.87
V	.39	.69	.05	.64
Cr	.47	.12	.84	.94
Mn	.28	.11	.53	.37
Fe	.84	.42	.32	.99
Ni	.42	.78	.18	.81
Zn	.26	.76	-.44	.83
TSP	.07	.81	.20	.71
Total variation, %	59.1	19.1	8.4	86.7
Common variation, %	70.6	21.5	7.9	
Eigenvalue	6.96	2.12	.78	

[a] Based on 23 samples.

☐ HEAVY FACTOR LOADINGS, ≥0.60

⬚ MODERATE FACTOR LOADINGS, 0.40 TO 0.59

TABLE E-4. VISALIA ROTATED FACTOR MATRIX[a]

Variable	Soil factor	Auto factor	Fuel oil factor	Secondary sulfate factor	Unidentified Cr/Ti factor	Commonality, h^2
Al	$\boxed{.98}$	-.08	.10	-.06	-.15	1.01
Mg	$\boxed{.97}$	-.07	.13	.10	.12	.99
P	$\boxed{.70}$	-.01	$\boxed{.61}$	-.10	.08	.88
S	.21	.48	.38	.35	.13	.56
K	$\boxed{.94}$	-.04	.23	.13	.13	.97
Ti	$\boxed{.62}$	-.09	.03	-.30	-.48	.72
V	.08	-.07	$\boxed{.88}$	.19	-.02	.83
Cr	.39	-.07	.05	-.13	.57	.50
Mn	$\boxed{.87}$	.10	.42	.08	.12	.96
Fe	$\boxed{.94}$	-.03	.26	.14	.13	.99
Ni	$\boxed{.76}$	-.06	.01	.11	.06	.60
Br	-.28	.57	-.14	.02	-.04	.43
Pb	-.06	$\boxed{.93}$	-.05	-.05	-.02	.88
Cl	-.45	-.38	-.14	.04	-.01	.37
$SO_4^=$	.12	.18	.17	$\boxed{.91}$	-.07	.90
TSP	$\boxed{.82}$	.14	.26	-.07	.13	.78
WS	-.07	$\boxed{-.81}$	-.04	-.29	.00	.75
DR	$\boxed{.78}$	.16	-.21	.18	.21	.76
AM	$\boxed{.78}$	-.35	-.15	.00	-.00	.76
Total variation, %	47.2	16.0	8.7	5.9	5.3	83.1
Common variation, %	60.3	18.9	9.9	6.4	4.6	
Eigenvalue	8.83	2.77	1.45	.93	.67	

[a] Based on 21 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

☐ HEAVY FACTOR LOADINGS, ≥0.60

⬚ MODERATE FACTOR LOADINGS, 0.40 TO 0.59

TABLE E-5. PARLIER ROTATED FACTOR MATRIX[a]

Variable	Soil factor	Unidentified S/Br/Ni factor	Dry soil factor	Auto/maritime air factor	Sulfate transport factor	Commonality, h^2
Al	.90	.07	.41	-.04	.02	1.00
Mg	.87	-.01	.45	-.08	.10	.98
S	.25	.62	-.01	-.14	-.02	.47
K	.88	.17	.44	.02	.07	1.00
Ti	.91	.01	.35	.08	-.05	.95
V	.71	.18	-.15	.04	-.20	.60
Cr	.71	.38	.15	-.12	-.28	.76
Mn	.88	.35	.09	-.05	.11	.91
Fe	.94	.07	.34	.03	-.01	.99
Ni	.23	.41	.56	-.07	-.13	.56
Br	-.07	.94	.14	-.21	.10	.96
Pb	-.12	.02	.00	-.56	.23	.38
Cl	-.43	-.16	.14	.48	.07	.46
$SO_4^=$	.01	.02	-.07	-.13	.70	.51
TSP	.74	.34	.12	-.14	.37	.83
WS	.04	-.34	-.18	.93	.01	1.02
DR	.52	-.02	.83	-.05	.07	.97
AM	.86	-.16	.01	.15	-.06	.78
Total variation, %	50.2	14.8	7.7	7.1	5.8	85.7
Common variation, %	63.2	17.4	7.4	6.9	5.0	
Eigenvalue	8.92	2.46	1.05	.98	.71	

[a] Based on 22 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

☐ HEAVY FACTOR LOADINGS, ≥0.60

⬚ MODERATE FACTOR LOADINGS, 0.40 TO 0.59

TABLE E-6. FRESNO (CAL STATE) ROTATED FACTOR MATRIX[a]

Variable	Soil factor	Secondary sulfate factor	Auto factor	Maritime air factor	Commonality, h^2
Al	.95	.19	.20	-.10	.99
Mg	.96	.19	.11	-.12	.99
S	.28	.87	.29	-.07	.92
K	.93	.23	.22	-.10	.97
Ti	.92	.02	.28	-.09	.93
V	.80	.24	-.07	-.00	.70
Cr	.88	.20	.14	.03	.84
Mn	.92	.30	.04	-.08	.95
Fe	.96	.09	.24	-.07	.99
Ni	.90	.11	.17	-.12	.86
Br	.37	.08	.77	-.03	.74
Pb	.08	.34	.86	-.08	.86
Cl	-.13	-.08	-.08	.82	.71
$SO_4^=$	.21	.79	.01	.03	.67
TSP	.62	.54	.38	-.12	.84
WS	-.03	-.59	-.46	.33	.67
DR	.87	.24	.23	-.06	.87
AM	.80	.04	-.45	.07	.85
Total variation, %	61.6	15.2	7.3	5.5	89.6
Common Variation, %	71.7	16.6	7.1	4.6	
Eigenvalue	10.99	2.55	1.10	.70	

[a] Based on 22 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

☐ HEAVY FACTOR LOADINGS, ≥0.60

⬚ MODERATE FACTOR LOADINGS, 0.40 TO 0.59

TABLE E-7. FIVE POINTS ROTATED FACTOR MATRIX[a]

Variable	Soil factor	Secondary sulfate factor	Soil factor II	Maritime air factor	Commonality, h^2
Al	$\boxed{.83}$	.07	.52	-.02	.97
Mg	$\boxed{.86}$	-.04	.48	.05	.97
P	$\boxed{.77}$	.04	.35	.17	.75
S	.34	$\boxed{.79}$	.24	.40	.96
K	$\boxed{.81}$	.10	.35	.29	.87
Ti	.24	-.02	$\boxed{.64}$	.13	.48
V	$\boxed{.70}$	-.23	.04	-.02	.54
Cr	.55	.11	$\boxed{.62}$	.21	.74
Mn	$\boxed{.61}$	.25	.36	.01	.57
Fe	$\boxed{.83}$	.14	.49	.11	.97
Ni	$\boxed{.80}$	.26	.33	.22	.87
Cl	-.18	.06	-.07	-.49	.28
$SO_4^=$	-.15	$\boxed{.85}$	-.03	-.04	.75
TSP	$\boxed{.83}$	-.10	.23	.12	.77
WS	.17	-.29	-.16	$\boxed{-.94}$	1.01
DR	.44	.05	$\boxed{.76}$	.12	.78
AM	$\boxed{.68}$	-.40	.24	-.13	.70
Total variation, %	54.9	14.6	7.4	5.8	82.6
Common variation, %	70.4	17.9	7.2	4.5	
Eigenvalue	9.14	2.32	.94	.58	

[a] Based on 24 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

☐ HEAVY FACTOR LOADINGS, ≥0.60

⬚ MODERATE FACTOR LOADINGS, 0.40 TO 0.59

TABLE E-8. MERCED ROTATED FACTOR MATRIX[a]

Variable	Soil factor	Auto & reent. dust factor	Fuel oil factor	Wind speed factor	Commonality, h^2
Al	.91	.38	.11	-.14	.99
Mg	.96	.19	.10	-.10	.99
P	.74	.57	.03	-.07	.89
S	.37	.86	.16	.01	.91
K	.90	.39	.16	-.10	1.00
Ti	.90	.35	.03	-.09	.94
V	.07	-.03	.74	-.00	.55
Cr	.64	.62	.27	.19	.91
Mn	.81	.46	.19	.11	.91
Fe	.90	.40	.17	-.10	1.00
Ni	.68	.47	.32	-.35	.90
Br	.17	.74	.11	-.31	.69
Pb	.06	.85	-.03	-.17	.75
Cl	-.15	-.14	-.15	.02	.06
$SO_4^=$	.18	.50	.49	.17	.55
TSP	.38	.80	.21	.14	.86
WS	.09	-.43	-.57	.40	.68
DR	.74	-.10	-.06	.24	.62
AM	.78	-.14	-.09	.31	.73
Total variation, %	57.3	15.0	7.0	5.0	84.4
Common variation, %	72.3	17.5	6.5	3.8	
Eigenvalue	10.79	2.60	.96	.57	

[a] Based on 23 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

☐ HEAVY FACTOR LOADINGS, $\geq$0.60

⬚ MODERATE FACTOR LOADINGS, 0.40 TO 0.59

TABLE E-9. MODESTO (J ST) ROTATED FACTOR MATRIX[a]

Variable	Soil factor	Auto & reent. dust factor	Fuel oil factor	Maritime air factor	Unidentified Al factor	Commonality, h^2
Al	.26	.01	.06	-.02	.79	.69
Mg	.79	.22	.18	.09	.25	.77
P	.25	.75	.07	-.01	.08	.64
S	.41	.80	.08	.30	.10	.92
K	.82	.46	.07	.20	.13	.94
Ti	.77	.31	.03	.24	.35	.86
V	.59	.09	-.57	.33	-.06	.79
Cr	.75	.20	.17	.21	.03	.68
Mn	.97	.19	.16	.13	-.01	1.01
Fe	.87	.35	.14	.12	.24	.96
Ni	.72	.43	.15	.16	.01	.74
Br	.15	.95	-.09	-.14	-.11	.95
Pb	.29	.86	-.34	.08	-.04	.94
Cl	-.24	.10	-.13	-.86	-.11	.84
$SO_4^=$	.33	.48	.32	.47	-.01	.67
TSP	.61	.68	-.01	.22	.17	.91
WS	-.18	-.23	.32	-.54	.23	.53
DR	.24	-.09	.85	.14	-.07	.82
AM	.35	-.05	.73	-.02	.17	.69
Total variation, %	50.2	15.4	9.2	7.0	4.5	86.3
Common variation, %	61.0	17.9	9.8	7.0	4.2	
Eigenvalue	9.4	2.76	1.51	1.08	.64	

[a] Based on 22 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

☐ HEAVY FACTOR LOADINGS, $\geq$0.60

⬚ MODERATE FACTOR LOADINGS, 0.40 TO 0.59

TABLE E-10. WOODLAND ROTATED FACTOR MATRIX[a]

Variable	Soil factor	Auto factor	Fertilizer fuel oil factor	Secondary sulfate factor	AB factor	Commonality, h^2
Al	.89	.18	.38	-.00	.04	.98
Mg	.90	.17	-.01	-.09	.05	.85
P	.28	-.16	.76	.03	-.01	.68
S	.43	.72	.09	.17	.14	.75
K	.89	.27	.06	-.07	.26	.95
Ti	.88	.29	-.29	-.12	-.09	.98
V	.49	.20	-.72	-.24	.32	.96
Cr	.70	.35	-.36	.09	.32	.86
Mn	.83	.27	-.07	.19	.29	.89
Fe	.95	.25	.12	.01	.10	.98
Ni	.93	.13	-.08	-.04	-.15	.91
Pb	.05	.57	-.19	-.23	.07	.42
Cl	-.10	-.26	.04	.51	-.00	.35
$SO_4^=$	.17	.07	.08	.97	-.15	1.00
TSP	.74	.57	.18	-.02	.16	.94
WS	-.10	-.64	.17	.10	.02	.45
DR	.68	-.12	.40	.14	.15	.68
AM	.84	-.30	.05	.13	.28	.89
AB	.16	.10	-.08	-.13	.79	.69
Total variation, %	50.2	15.0	7.7	7.4	5.4	85.7
Common variation, %	62.1	16.8	8.3	7.5	5.3	
Eigenvalue	9.43	2.56	1.26	1.14	.81	

[a] Based on 21 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

☐ HEAVY FACTOR LOADINGS, ≥0.60

⬚ MODERATE FACTOR LOADINGS, 0.40 TO 0.59

TABLE E-11. LIVE OAK ROTATED FACTOR MATRIX[a]

Variable	Soil factor 1	Unidentified V/Cr/Ti/Mn factor 2	Secondary sulfate factor	Unidentified P factor	AB factor	Commonality, h^2
Al	.92	.02	.17	.21	.20	.95
Mg	.74	.55	.06	.12	.09	.88
P	.06	.07	-.04	.89	.05	.81
S	.54	.11	.08	-.39	.39	.61
K	.77	.47	-.13	-.20	-.06	.87
Ti	.57	.71	.10	-.02	.23	.90
V	.20	.91	.08	-.14	.02	.89
Cr	.34	.81	-.03	.23	-.18	.87
Mn	.60	.67	.08	.17	-.15	.86
Fe	.90	.36	.19	.08	.09	.99
Ni	.71	.28	.35	.03	-.30	.79
Pb	.01	-.48	-.13	-.02	.17	.28
$SO_4^=$	.40	-.02	.74	-.04	-.05	.72
TSP	.86	.20	.06	.04	.09	.79
WS	.02	.21	.71	-.00	.14	.58
DR	.79	-.01	.48	-.16	-.05	.88
AM	.64	.47	.18	-.14	.03	.67
AB	-.05	.12	-.05	-.03	-.51	.28
Total variation, %	49.5	12.3	8.0	7.6	6.1	83.6
Common variation, %	64.3	14.5	8.7	7.8	4.6	
Eigenvalue	8.76	1.98	1.18	1.06	.63	

[a] Based on 22 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

☐ HEAVY FACTOR LOADINGS, ≥0.60

⬚ MODERATE FACTOR LOADINGS, 0.40 TO 0.59

TABLE E-12. CHICO ROTATED FACTOR MATRIX[a]

Variable	Soil factor	Auto factor	Fuel oil factor	Dry soil factor	Fertilizer factor	Commonality, h^2
Al	$\boxed{.83}$	.08	-.11	.35	-.25	.89
Mg	$\boxed{.92}$	.05	-.04	.09	.19	.89
P	.19	.18	-.07	.04	$\boxed{.90}$	.88
S	$\boxed{.59}$	$\boxed{.59}$	.14	.18	.33	.86
K	$\boxed{.81}$	.22	.22	.20	.10	.80
Ti	$\boxed{.90}$	.07	.02	.26	-.30	.97
V	.20	.09	$\boxed{.88}$	-.12	-.04	.84
Cr	$\boxed{.81}$	.01	$\boxed{.40}$	-.04	.09	.82
Mn	$\boxed{.89}$	.09	.35	.15	-.05	.94
Fe	$\boxed{.97}$	.09	.02	.21	-.06	.99
Ni	$\boxed{.77}$	-.03	.06	-.14	-.08	.63
Br	-.03	$\boxed{.95}$	.10	-.20	.07	.96
Pb	.12	$\boxed{.95}$	.01	-.19	.03	.95
Cl	-.32	.03	-.07	-.36	.04	.24
$SO_4^{=}$	.09	-.25	-.30	$\boxed{.48}$	.16	.42
TSP	$\boxed{.70}$	$\boxed{.49}$	.03	.28	.04	.81
WS	.01	$\boxed{-.52}$	$\boxed{-.48}$	-.32	.08	.61
DR	$\boxed{.56}$	-.12	.08	$\boxed{.58}$	.20	.70
AM	$\boxed{.56}$	-.05	-.14	.31	-.01	.43
AB	.22	.03	.01	-.04	$\boxed{-.42}$	.23
Total variation, %	43.9	15.4	9.1	6.4	5.9	80.7
Common variation, %	57.9	19.5	10.3	7.2	5.0	
Eigenvalue	8.60	2.90	1.53	1.08	.74	

[a] Based on 24 samples.

WS = wind speed

DR = days since >0.25 in. rain

AM = atmospheric moisture

AB = agricultural burning

☐ HEAVY FACTOR LOADINGS, ≥0.60

⬚ MODERATE FACTOR LOADINGS, 0.40 TO 0.59

TABLE E-13. FORT BRAGG ROTATED FACTOR MATRIX[a]

Variable	Soil factor	Unidentified factor	Unidentified factor	Commonality, h^2
Al	.88	.21	.19	.85
Mg	.97	.11	-.04	.95
P	.08	.12	.98	.99
S	.23	.80	.06	.69
K	.46	.81	.19	.91
Ti	.91	.17	.13	.88
Cr	.86	.16	.01	.76
Mn	.82	.43	.08	.87
Fe	.95	.26	.01	.97
Cl	.01	.51	-.01	.26
TSP	.26	.81	.08	.73
Total variation, %	59.0	16.8	9.1	84.8
Common variation, %	71.7	17.8	10.6	
Eigenvalue	6.35	1.57	.94	

[a] Based on 19 samples.

▭ HEAVY FACTOR LOADINGS, ≥0.60

⬚ MODERATE FACTOR LOADINGS, 0.40 TO 0.59

TABLE E-14. PASO ROBLES ROTATED FACTOR MATRIX[a]

Variable	Soil factor	Unidentified Mg/P factor	Auto factor	Unidentified Cr/Ni factor	Aged aerosol factor	Commonality, h^2
Al	.68	-.12	-.08	.37	-.37	.76
Mg	.08	.93	.04	.17	-.21	.96
P	.01	.96	.16	-.06	.21	1.00
S	.95	-.08	-.04	.24	.09	.97
K	.86	.01	-.06	.40	-.01	.90
Ti	.59	.22	-.04	.52	.19	.71
Cr	.57	-.04	-.06	.73	.34	.98
Mn	.80	.11	-.01	.25	.36	.84
Fe	.92	-.00	-.15	.26	.10	.95
Ni	.25	-.02	.11	.70	-.11	.58
Br	-.07	-.05	-.04	-.02	-.42	.19
Pb	-.05	.09	.95	.06	.07	.92
Cl	-.23	.44	-.11	-.12	.24	.33
$SO_4^=$	.86	-.05	-.19	.15	.37	.94
NO_3	.79	-.05	.18	.14	-.00	.67
BSO	.73	-.08	.15	.06	-.08	.57
TSP	.96	-.01	-.06	.18	-.05	.96
Total variation, %	50.1	13.7	7.7	6.8	6.1	84.5
Common variation, %	63.3	16.6	8.0	6.3	5.8	
Eigenvalue	8.38	2.19	1.06	.83	.76	

[a] Based on 24 samples.

☐ HEAVY FACTOR LOADINGS, ≥0.60

⬚ MODERATE FACTOR LOADINGS, 0.40 TO 0.59

APPENDIX F

MICROINVENTORY SUMMARIES OF CALIFORNIA SITES

This appendix presents a five page summary for each of the 22 sites in California where a microinventory was performed. These sites are presented in the following order:

Bakersfield (Flower)
Bakersfield (Chester)
Taft
Kern Refuge
Kettleman City
Visalia
Parlier
Fresno (Olive)
Fresno (Cal State)
Five Points
Coalinga
Merced
Modesto (J St)
Stockton
Sacramento (P St)
Woodland
Sutter City
Live Oak
Chico
Red Bluff
Fort Bragg
Paso Robles

DESCRIPTION OF SITE

SAROAD code - 050520003I01

Location - 1700 Flower Street, Bakersfield

UTM coordinates - 321.0, 3917.9

Monitor height - 18 ft, on roof of building

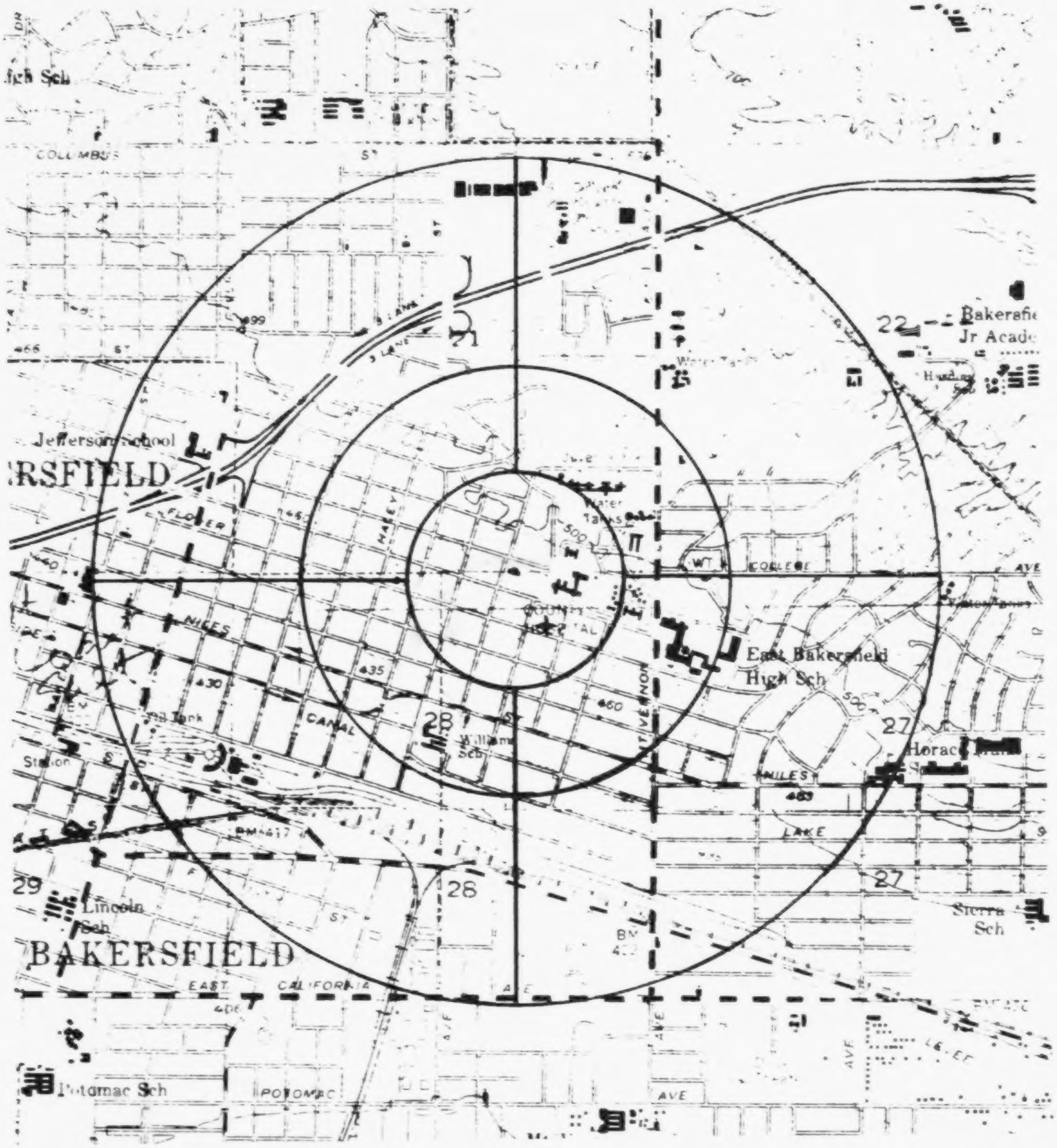
Topography - No special terrain

Localized sources, within 200 ft of monitor -

Source	Distance	Description
Flower Street	66 ft	8500 ADT, clean, curbed
Virginia Street	180 ft	1000 ADT, clean, curbed

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	127.3	60
1976	124.1	60
1975	132.4	58
1974	128.0	54
1973	138.9	61


COLUMBUS ST
Jefferson School
RSFIELD
FLOWER
NILES
CANAL
HALEY
Water Tanks
COLLEGE AVE
East Bakersfield High Sch
William Sch
NILES
LAKE
Lincoln Sch
BAKERSFIELD
EAST CALIFORNIA AVE
Potomac Sch
POTOMAC
Sierra Sch
Bakersfie
Jr Acade
21
22
27
28
29

One mile radius around 1700 Flower Street, Bakersfield site.

Viewed to the north.

View to the west-northwest.

Sampler at 1700 Flower Steet, Bakersfield.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates x	UTM coordinates y
1	West Coast Salt	37	1.6	4	318.6	3916.8
2	Chevron	75	2.4	1	321.3	3921.8
3	Chevron	108	2.8	1	320.4	3922.3
4	West Coast Oil	33	2.8	4	317.7	3921.1
5	Chevron	90	2.9	4	317.6	3921.1
6	Chanslor Western Oil	34	3.0	1	320.8	3922.8
7	Getty Oil	79	3.0	1	320.7	3922.8
8	Chevron	161	3.1	1	322.4	3922.7
9	Chevron	29	3.1	1	320.6	3922.8
10	Chanslor Western Oil	59	3.2	1	322.1	3923.0
11	Getty Oil	144	3.3	1	319.1	3922.8
12	Getty Oil	29	3.3	1	321.0	3923.2
13	Getty Oil	360	3.3	1	320.1	3923.2
14	Getty Oil	153	3.4	1	319.0	3923.0
15	WITCO Refinery	122	3.4	4	316.7	3921.4
16	Chevron	99	3.6	1	318.9	3923.3
17	Getty Oil	432	3.9	1	320.4	3924.1
18	Getty Oil	576	4.0	1	319.8	3924.3
19	Chevron	53	4.1	1	320.0	3924.5
20	Getty Oil	421	4.1	1	320.0	3924.5
21	Consolidated Fiberglass	41	4.2	4	314.2	3918.4
22	Getty Oil	433	4.2	1	321.4	3924.7

POINT SOURCE SUMMARY (Continued)

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates	
					x	y
23	Getty Oil	144	4.2	1	317.6	3923.8
24	San Joaquin Refinery	102	4.2	4	314.3	3918.7
25	Getty Oil	154	4.3	1	318.7	3924.5
26	Getty Oil	216	4.4	1	319.5	3924.8
27	Chevron	68	4.5	1	317.2	3924.0
28	Getty Oil	72	4.7	1	320.6	3925.4
29	Getty Oil	306	5.0	1	318.7	3925.7

AREA SOURCE SUMMARY

Site: 1700 Flower Street, Bakersfield

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	2.4
Comm/Ind fuel		2.0	0.7	1.0	0.2		3.0	1.0	4.0	1.0	12.9
Incinerators											
Rail/Air								2.4	3.5		5.9
Auto exhaust	7.0x10^{7} VMT	1.0	1.5	2.6	1.8	0.9	3.1	7.0	10.1	11.3	39.3
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards	62 ac							11.2	46.5		57.7
Clean streets	6.8x10^{7} VMT	8.8	14.0	23.8	16.1	7.9	28.8	57.8	84.7	104.1	346.0
Comm streets	1.6x10^{6} VMT							14.6	18.4		33.0
Unpaved roads	3.6x10^{2} VMT						0.6				0.6
Cleared areas	6.6 ac	0.7			0.4	1.1	8.9		0.4	3.1	14.6
Construction	5 ac		32.4			16.2					48.6
Agriculture											
Storage areas	5 ac								14.5		14.5
Unpaved pkg lots	1.6x10^{4} VMT	8.8	0.6		0.2			0.5	1.6	2.6	14.3

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	3.3	9.6	47.6	60.5
IND PROCESSES				
FUGITIVE DUST	18.3	112.7	398.3	529.3
Total	21.6	122.3	445.9	589.8

DESCRIPTION OF SITE

SAROAD code - 050520003F01

Location - Chester Street, Bakersfield

UTM Coordinates - 316.6, 3914.5

Monitor height - 25 ft, on roof of building

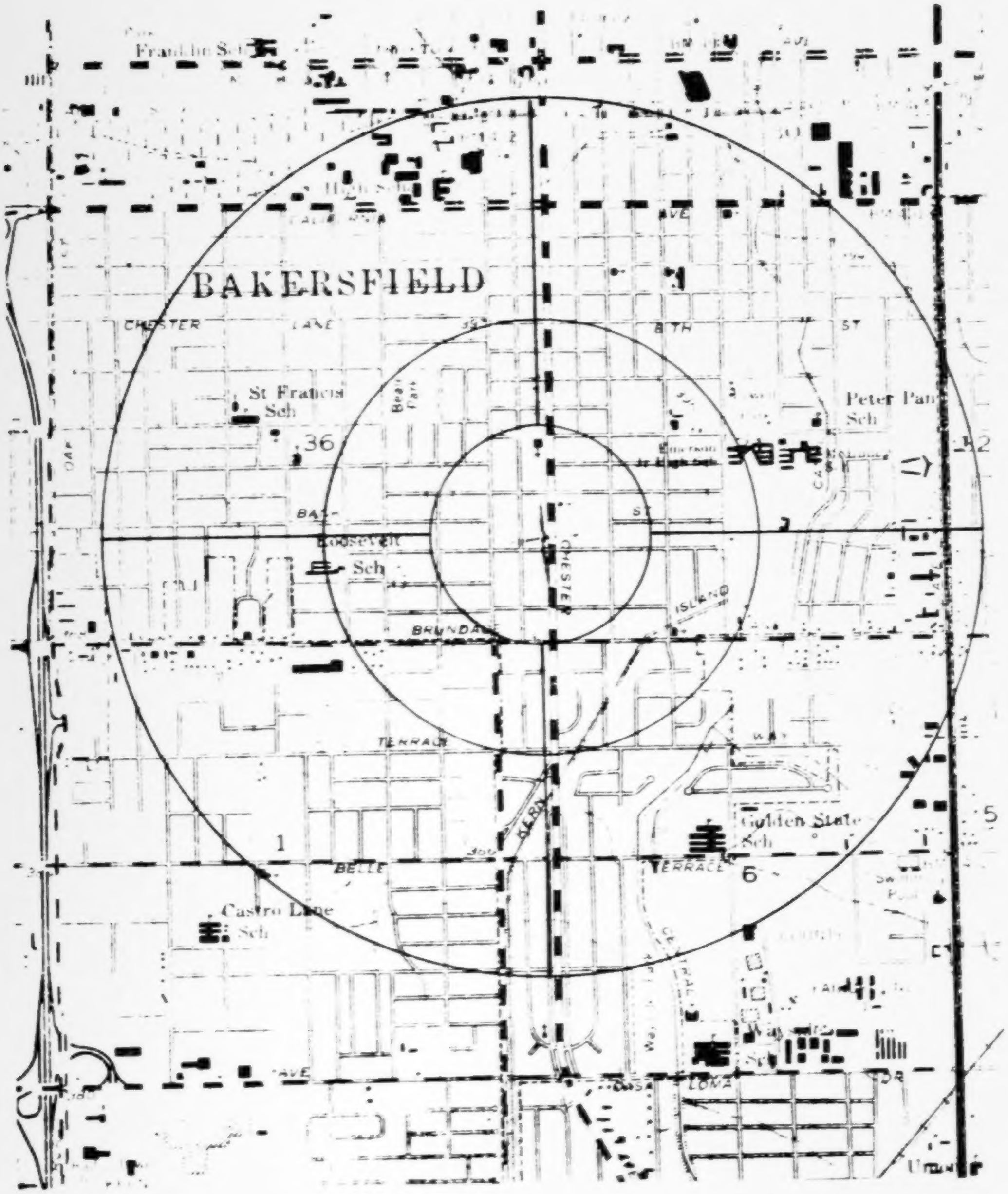
Topography - No special terrain

Localized sources, within 200 ft. of monitor -

Source	Distance	Description
Chester Street	56 ft	16,356 ADT, clean, curbed

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	154.9	65
1976	149.1	62
1975	138.7	63
1974	130.2	55
1973	116.2	57


BAKERSFIELD
Franklin Sch
High Sch
CHESTER
LANE
8TH
ST
St Francis Sch
Peter Pan Sch
36
Emerson Jr High Sch
BAY
ST
Roosevelt Sch
CHESTER
ISLAND
BRUNDAGE
TERRACE
WAY
KERN
Golden State Sch
1
BELLE
TERRACE
6
5
Castro Lane Sch
CENTRAL
AVE
LOMA
DR

One mile radius around Chester Street, Bakersfield site.

Viewed to the north.

Viewed to the south.

Sampler at Chester Street, Bakersfield.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates x	UTM coordinates y
1	West Coast Salt	37	1.9	1	318.6	3916.8
2	Consolidated Fiberglass	41	2.8	1	314.2	3918.4
3	San Joaquin Refinery	102	3.0	1	314.3	3918.7
4	IMC Corporation	40	3.2	4	311.8	3916.4
5	TOSCO Oil	553	3.2	4	311.9	3916.4
6	Mohawk Petroleum	74	3.4	4	311.6	3916.5
7	Chevron	90	4.2	1	317.6	3921.1
8	West Coast Oil	33	4.2	1	317.7	3921.1
9	WITCO Refinery	122	4.3	1	316.7	3921.4
10	PG&E	155	4.5	4	309.7	3916.9

AREA SOURCE SUMMARY

Site: Chester Street, Bakersfield

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.1	0.1	0.1	0.1	0.1	0.4	0.4	0.4	0.4	2.1
Comm/Ind fuel							0.2	0.2	0.1	0.5	1.0
Incinerators											
Rail/Air							0.1			0.1	0.2
Auto exhaust	1.0x10^8 VMT	7.6	3.6	5.4	5.5	1.7	10.8	5.8	7.9	7.6	55.9
INDUS PROCESSES:											
Ind processes			1.0								
FUGITIVE DUST:											
Railroad yards											
Clean streets	1.0x10^8 VMT	69.8	32.7	49.9	50.6	15.4	99.0	53.3	72.3	69.4	512.4
Comm streets											
Unpaved roads	4.6x10^2 VMT								0.8		0.8
Cleared areas	22.4 ac	4.4	6.1	11.5	0.5		17.6	6.1	8.5		54.7
Construction	16 ac			32.4	32.4			54.0	54.0		172.8
Agriculture											
Storage areas	2 ac			6.3							6.3
Unpaved pkg lots	6.3x10^3 VMT	0.5	0.1				0.3	4.6	0.1	0.1	5.7

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	7.7	16.6	34.9	59.2
IND PROCESSES		1.0		1.0
FUGITIVE DUST	74.7	237.9	440.1	752.7
Total	82.4	255.5	475.0	812.9

DESCRIPTION OF SITE

SAROAD code - 058140001I01

Location - 120 North 10th Street, Taft

UTM coordinates - 275.5, 3891.4

Monitor height - 6 ft, on ground level platform

Topography - No special terrain

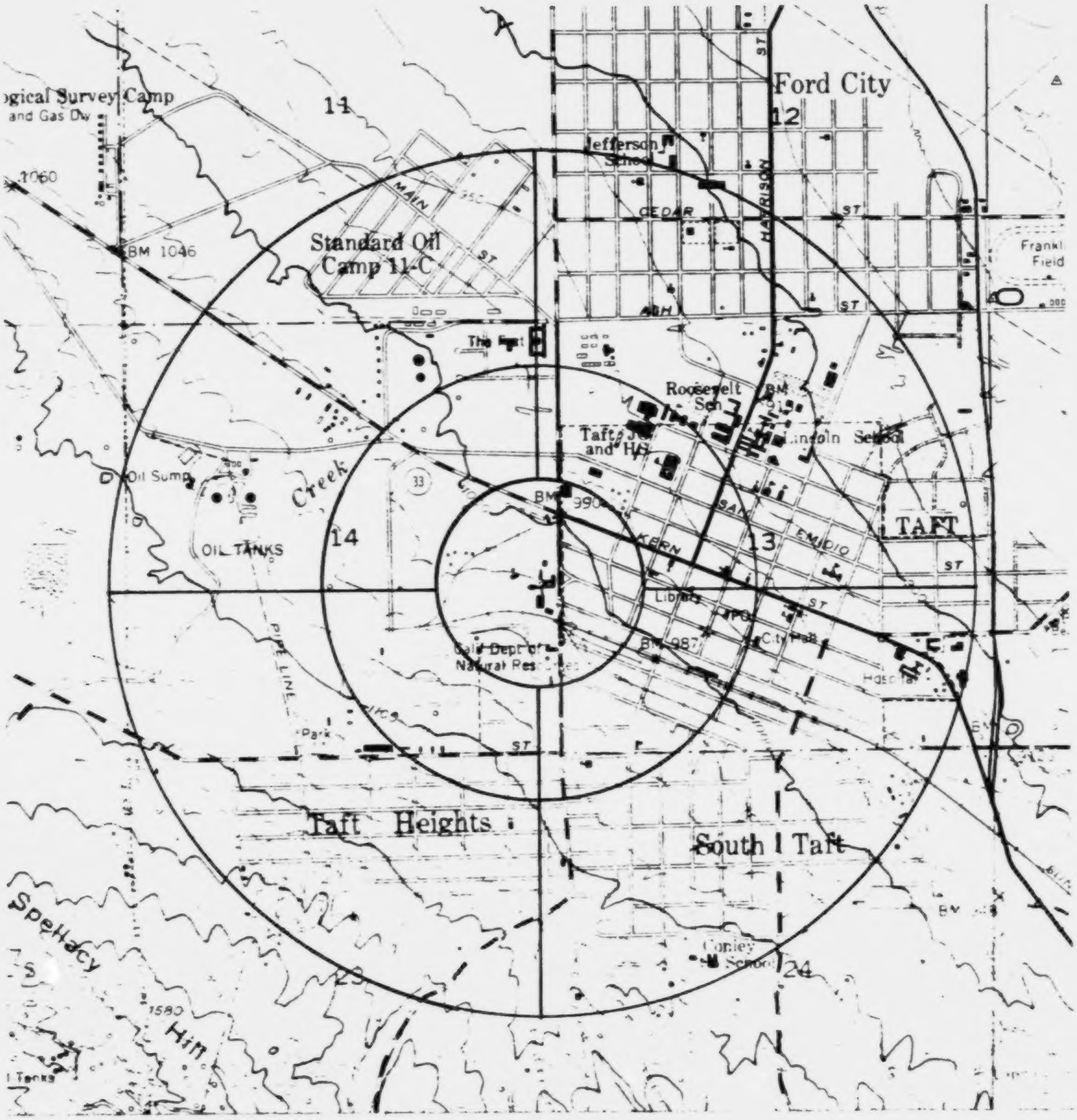
Localized sources, within 200 ft of monitor -

Source	Distance	Description
Service drive	5 ft	dirty, uncurbed
Parking lot	30 ft	unpaved
Private street	20 ft	200 ADT, clean, curbed

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	103.2	57
1976	99.6	44
1975[a]	125.6	26

[a] May not represent year's average.


Ford City
12
Jefferson School
CEDAR
HARRISON
ST
ASH
Frankl Field
Standard Oil Camp 11-C
MAIN
ST
BM 1046
1060
14
Roosevelt Sch
Lincoln School
Taft Jr. and HS
Oil Sump
OIL TANKS
Creek
33
14
BM 990
13
KERN
SAN EMIDIO
TAFT
ST
Library
City Hall
BM 987
Hospital
Calif Dept of Natural Res
PIPE LINE
Park
ST
Taft Heights
South Taft
Conley School
24
23
Spellacy Hill
1580
Tanks

One mile radius around 120 North 10th Street, Taft site.

Viewed to the southeast.

Viewed to the west.

Sampler at 120 N. 10th Street, Taft.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates x	UTM coordinates y
1	Chevron and Tenneco Oil	34	2.0	3	274.5	3888.4
2	Chanslor Western Oil	36	2.3	4	272.0	3890.2
3	Tenneco and Shell Oil	60	2.9	3	274.8	3886.8
4	Chanslor Western Oil	56	3.2	4	270.4	3892.0
5	Excel Mineral	72	3.2	2	280.0	3889.0
6	Atlantic Richfield	54	4.6	3	278.8	3884.8

AREA SOURCE SUMMARY

Site: 120 N. 10th Street, Taft

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel			0.1	0.1	0.1		0.3	0.3	0.2		1.1
Comm/Ind fuel		0.5	1.0	0.5			1.0	1.0		1.0	5.0
Incinerators											
Rail/Air		0.5		0.5				1.0			2.0
Auto exhaust	1.8x10^7 VMT	1.7	1.7	0.9	0.2	0.7	2.7	0.8	0.5	0.7	9.9
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards											
Clean streets	1.8x10^7 VMT	15.3	15.2	7.9	1.7	6.4	25.0	7.3	4.3	6.1	89.2
Comm streets											
Unpaved roads	1.9x10^3 VMT							0.4	1.6	1.3	3.3
Cleared areas	74 ac	23.7	1.8	4.4	1.5		10.2	8.8	0.7	2.9	54.0
Construction	0.5 ac								2.7		2.7
Agriculture											
Storage areas	3.5 ac			2.8				0.5			3.3
Unpaved pkg lots	1.2x10^4 VMT	1.3	0.1	0.8			0.2	7.8		1.4	11.6

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	2.7	5.8	9.5	18.0
IND PROCESSES				
FUGITIVE DUST	40.3	42.6	81.2	164.1
Total	43.0	48.4	90.7	182.1

DESCRIPTION OF SITE

SAROAD code - 053480001I03

Location - Kern National Wildlife Refuge

UTM coordinates - 266.7, 3961.2

Monitor height - 4 ft, on level ground

Topography - No special terrain

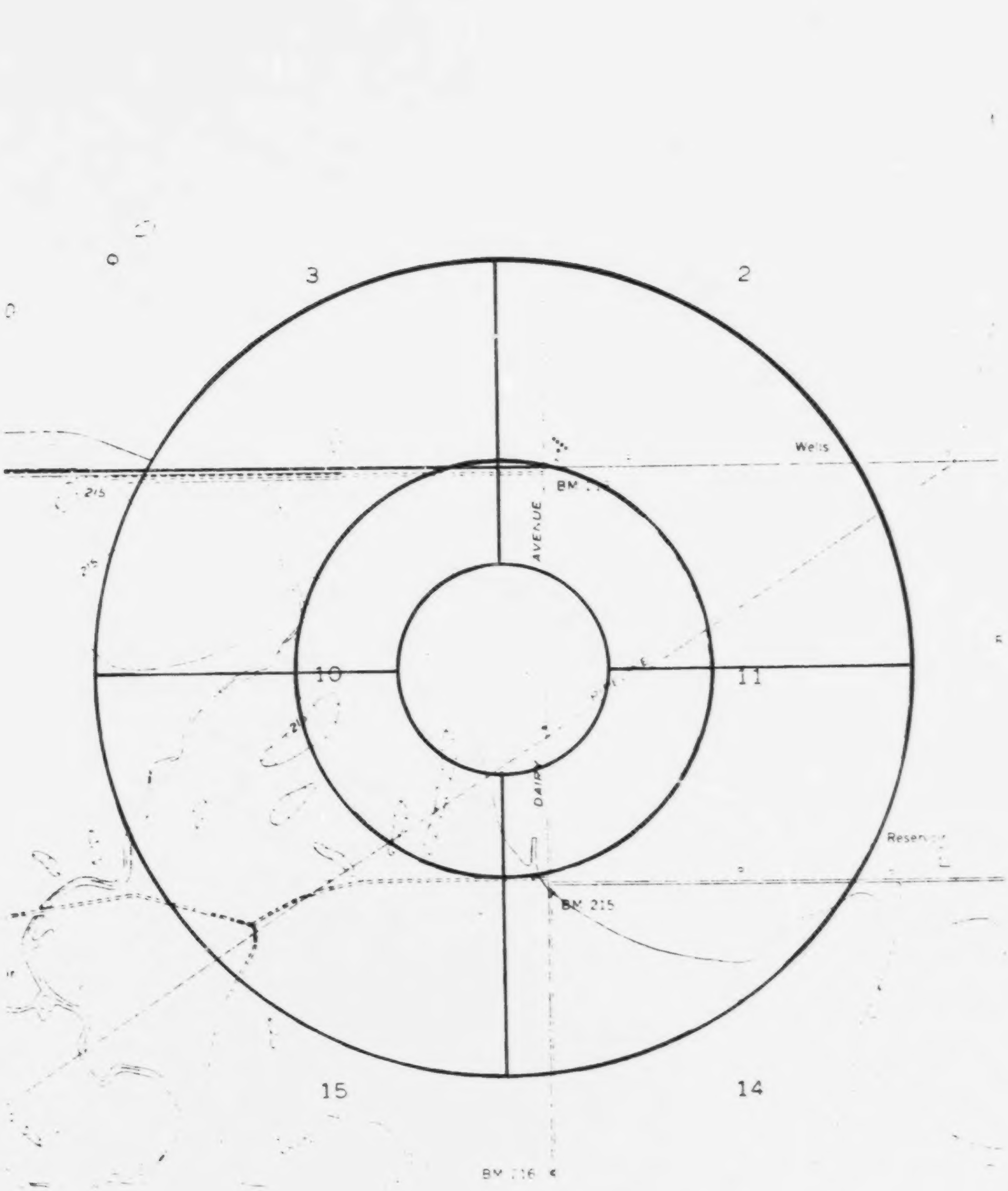
Localized sources, within 200 ft of monitor -

Source	Distance	Description
Exposed ground	Adjacent to sampler	100 ft x 60 ft
Unpaved lot	120 ft	2 cars per day, 90 ft x 75 ft

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	78.6	48
1976	83.9	48
1975[a]	79.2	28
1974	84.5	41
1973	86.8	49

[a] May not represent year's average.


3
2
Wells
215
BM
AVENUE
215
10
11
DAIRY
Reservoir
BM 215
15
14
BM 216

One mile radius around Kern National Wildlife Refuge site.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates x	UTM coordinates y
1	Shell Oil	29	3.9	3	262.0	3957.1

AREA SOURCE SUMMARY

Site: Kern National Wildlife Refuge

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel											
Comm/Ind fuel											
Incinerators											
Rail/Air											
Auto exhaust	348.7×10^3 VMT							0.1			0.1
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards											
Clean streets	348.7×10^3 VMT	0.2	0.1	0.1			0.2	0.6			1.2
Comm streets											
Unpaved roads	1691 VMT					0.4		0.1	1.3	1.2	3.0
Cleared areas	136.7 ac	0.1						136.7			136.8
Construction											
Agriculture	147.1 ac							10.3			10.3
Storage areas	1.5 ac								21.5		21.5
Unpaved pkg lots	10 ac								0.4		0.4

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION			0.1	0.1
IND PROCESSES				
FUGITIVE DUST	0.3	0.6	172.3	173.2
Total	0.3	0.6	172.4	173.3

DESCRIPTION OF SITE

SAROAD code - NA

Location - Kettleman City

UTM coordinates - 233.3, 3988.6

Monitor height - 20 ft, on roof of fire station

Topography - No special terrain

Localized sources, within 200 ft of monitor -

Source	Distance	Description
Highway 41	130 ft	2750 ADT, fairly clean, uncurbed

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977[a]	124.5	27
1976[a]	124.5	19

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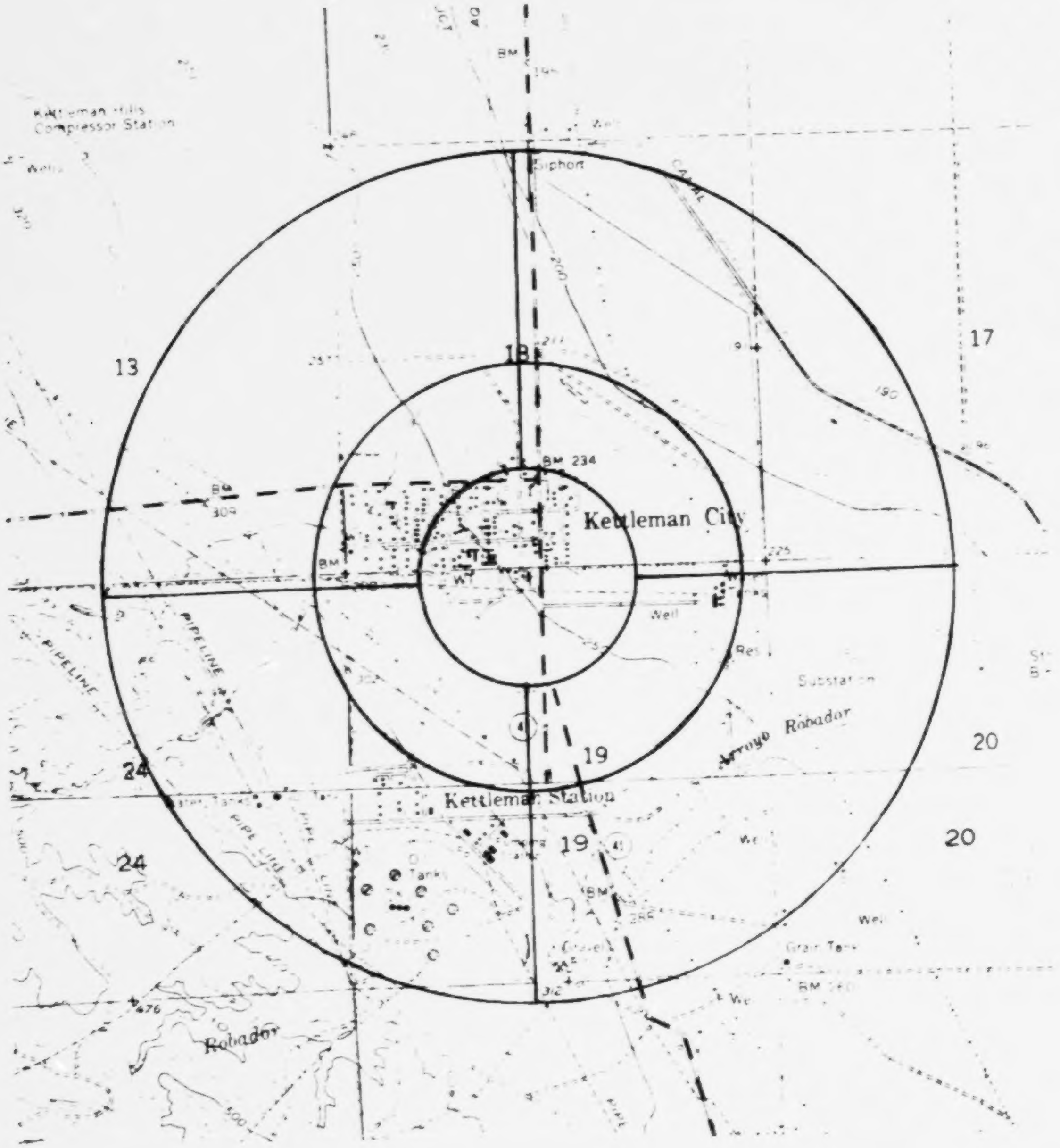
[a] May not represent year's average.


Kettleman Hills Compressor Station
Well
Siphon
CANAL
13
18
17
190
BM 234
BM 309
Kettleman City
PIPELINE
PIPELINE
Well
Res
Substation
Arroyo Robador
19
20
24
Kettleman Station
19
20
24
Tanks
BM
Gravel
Well
Grain Tank
476
Robador
500

One mile radius around Kettleman City site.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates	
					x	y
	No point sources listed within 5 mi of sampler.					

AREA SOURCE SUMMARY

Site: Kettleman City

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel											
Comm/Ind fuel											
Incinerators											
Rail/Air											
Auto exhaust	841.2x10^{3} VMT	0.2		0.1		0.2	0.1	0.1			0.7
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards											
Clean streets	685.6x10^{3} VMT	0.8	0.5	0.5		0.3	0.9	0.9		0.2	4.1
Comm streets	155.6x10^{3} VMT	4.8				1.6			0.3		6.7
Unpaved roads	68.8x10^{3} VMT	16.0	16.0	0.6		31.0	31.9	4.8	11.7	8.5	120.5
Cleared areas	66.5 ac	0.7						1.8	89.1		91.6
Construction											
Agriculture	936 ac	0.4	7.0		2.7		22.4	6.1		22.4	61.0
Storage areas	1.5 ac	7.2			14.3						21.5
Unpaved pkg lots	2 ac	0.4									0.4

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	0.2	0.3	0.2	0.7
IND PROCESSES				
FUGITIVE DUST	30.3	74.5	201.0	305.8
Total	30.5	74.8	201.2	306.5

DESCRIPTION OF SITE

SAROAD code - 058520001F01

Location - E. Oak Street, Visalia

UTM coordinates - 294.3, 4023.0

Monitor height - 25 ft, on roof of building

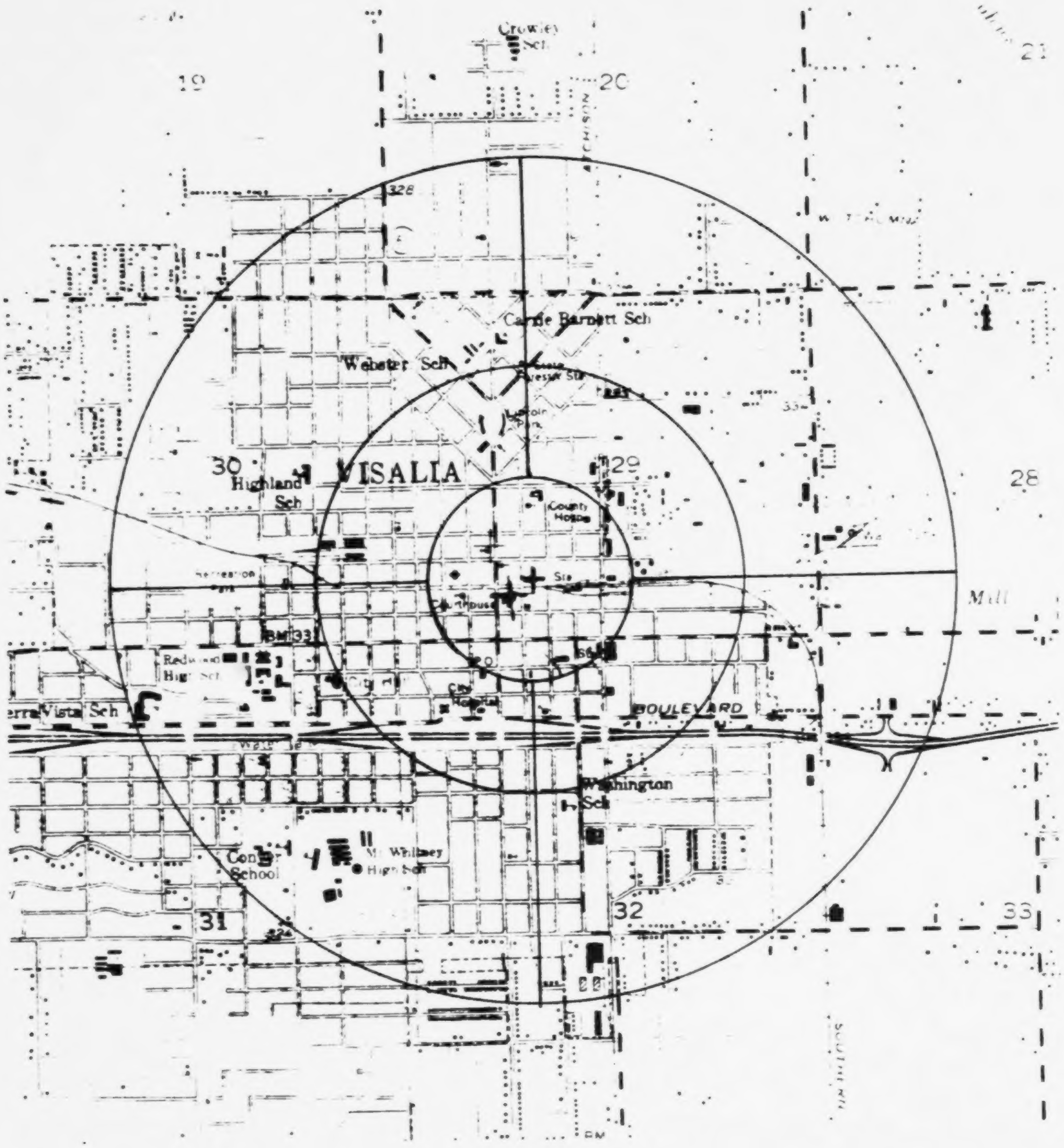
Topography - No special terrain

Localized sources, within 200 ft of monitor -

Source	Distance	Description
Oak Street	45 ft	1307 ADT, clean, curbed
Church Street	120 ft	1000 ADT, clean, curbed

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	127.6	58
1976	145.7	57
1975	141.7	56
1974	119.3	59
1973	108.0	56


Crowley Sch
19
20
21
328
Carrie Barnett Sch
Webster Sch
30
Highland Sch
VISALIA
29
28
County Hosp
Mill
BM331
Redwood High Sch
Sierra Vista Sch
City Hospital
BOULEVARD
Washington Sch
Conyer School
Mt Whitney High Sch
31
32
33

One mile radius around E. Oak Street, Visalia site.

Viewed to the southeast.

Viewed to the south.

Sampler at E. Oak Street, Visalia.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates	
					x	y

All point sources were included in the industrial process cateogry.

AREA SOURCE SUMMARY

Site: E. Oak Street, Visalia

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.4	0.2	0.2	0.3	0.3	0.2	0.3	1.0	1.0	3.9
Comm/Ind fuel		0.2			0.1	0.1	0.2	0.2	0.4		1.2
Incinerators											
Rail/Air		0.1		0.1				0.2		0.1	0.5
Auto exhaust	5.6x10^7 VMT	3.2	0.2	2.5	4.0	1.4	2.4	4.4	8.4	4.1	30.6
INDUS PROCESSES:											
Ind processes		2.0					32.4	4.0			38.4
FUGITIVE DUST:											
Railroad yards											
Clean streets	5.6x10^7 VMT	28.7	1.6	22.4	35.5	12.8	21.9	39.7	75.8	37.1	275.5
Comm streets											
Unpaved roads											
Cleared areas	35.6 ac	0.3	2.0					3.4		0.4	6.1
Construction	1 ac							10.8			10.8
Agriculture	9 ac						15.0	0.9			15.9
Storage areas	17.8 ac	0.1	0.2	10.7			23.4	8.0		0.2	42.6
Unpaved pkg lots	8.1x10^3 VMT	1.2	0.9	0.3		0.8	3.6			0.1	6.9

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	3.8	9.5	22.9	36.2
IND PROCESSES	2.0		36.4	38.4
FUGITIVE DUST	30.3	87.2	240.3	357.8
Total	36.1	96.7	299.6	432.4

DESCRIPTION OF SITE

SAROAD code - 052820001I01

Location - Kearny Field Station, Parlier

UTM coordinates - 275.7, 4053.5

Monitor height - 6 ft, on stablized dirt lot

Topography - No special terrain

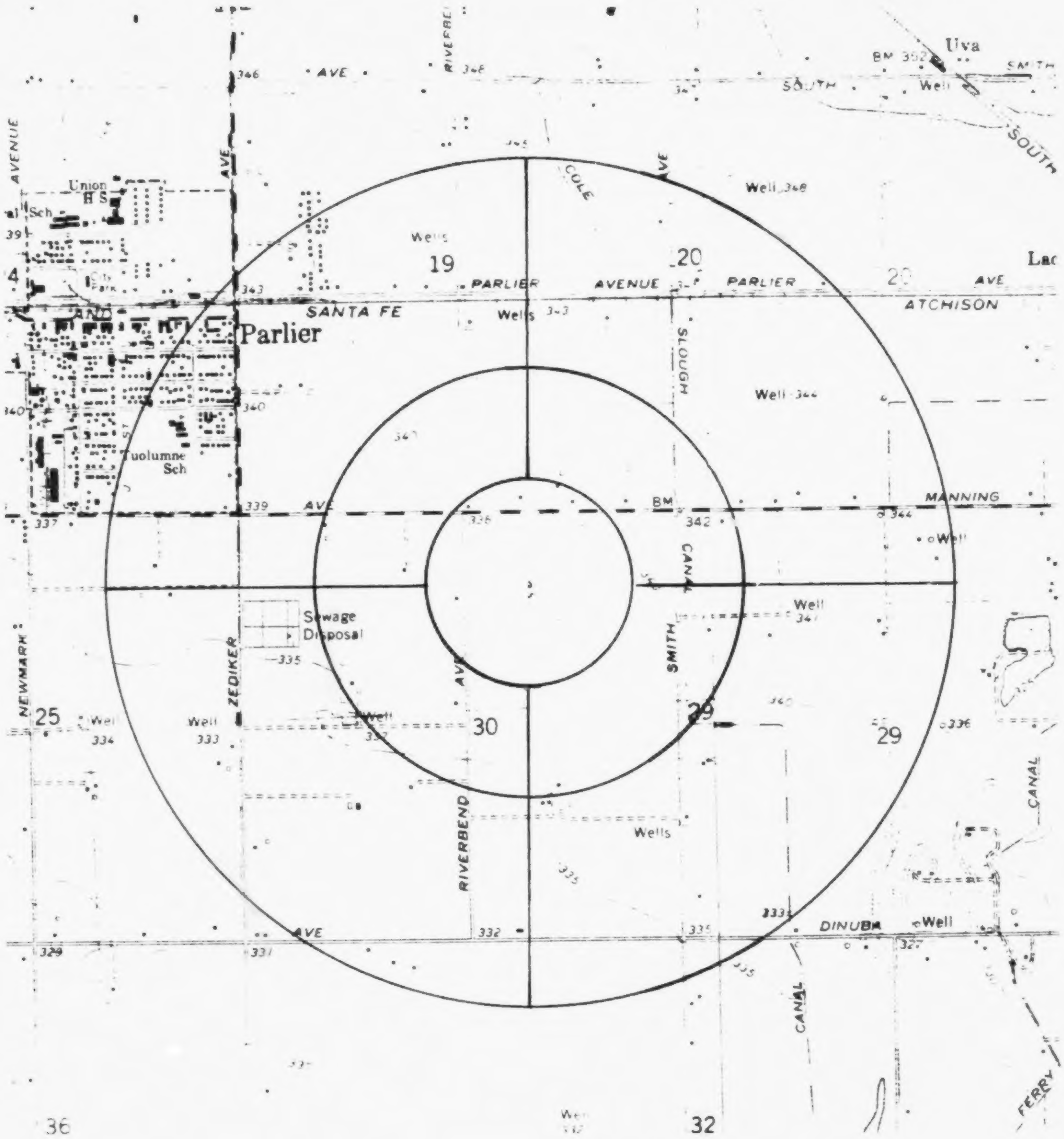
Localized sources, within 200 ft of monitor -

Source	Distance	Description
Access road	40 ft	low ADT, dirty, uncurbed
Access road	60 ft	low ADT, dirty, uncurbed
Agriculture	20 ft	tilled field
Agriculture	54 ft	tilled field

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	125.8	52
1976	133.2	60
1975[a]	106.2	55
1974[a]	68.7	25
1973	61.8	42

[a] May not represent year's average


Parlier
Union H S
Sch
Tuolumne Sch
Uva
Lac
SANTA FE
ATCHISON
PARLIER AVENUE
PARLIER AVE
MANNING AVE
DINUBA AVE
AVENUE
AVE
ZEDIKER
NEWMARK
RIVERBEND AVE
SMITH
COLE AVE
SLOUGH
CANAL
FERRY
SOUTH
SMITH
Sewage Disposal
Wells
Well
BM
19
20
25
29
30
32
36

One mile radius around Kearny Field Station, Parlier site.

Viewed to the north.

Viewed to the east.

Sampler at Kearny Field Station, Parlier.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates	
					x	y
	No point sources listed within 5 mi of sampler.					

AREA SOURCE SUMMARY

Site: Kearny Field Station, Parlier

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel										0.3	0.3
Comm/Ind fuel										0.1	0.1
Incinerators										0.1	0.1
Rail/Air										0.1	0.1
Auto exhaust	5.2×10^6 VMT	0.4	0.2			0.2	0.7	0.1	0.3	0.9	2.8
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards											
Clean streets	5.2×10^6 VMT	3.3	2.3	0.2		2.1	6.2	0.7	2.9	7.9	25.6
Comm streets											
Unpaved roads	1.4×10^3 VMT									2.3	2.3
Cleared areas	0.1 ac										
Construction											
Agriculture	1649 ac	12.8	5.8	6.0	3.8	6.3	21.2	41.5	22.5	20.0	139.9
Storage areas											
Unpaved pkg lots	6.2×10^2 VMT	0.4								0.1	0.5

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	0.4	0.4	2.6	3.4
IND PROCESSES				
FUGITIVE DUST	16.5	26.5	125.3	168.3
Total	16.9	26.9	127.9	171.7

DESCRIPTION OF SITE

SAROAD code - 052800005F01

Location - Olive Street, Fresno

UTM coordinates - 252.8, 4071.4

Monitor height - 10 ft, on roof of building

Topography - No special terrain

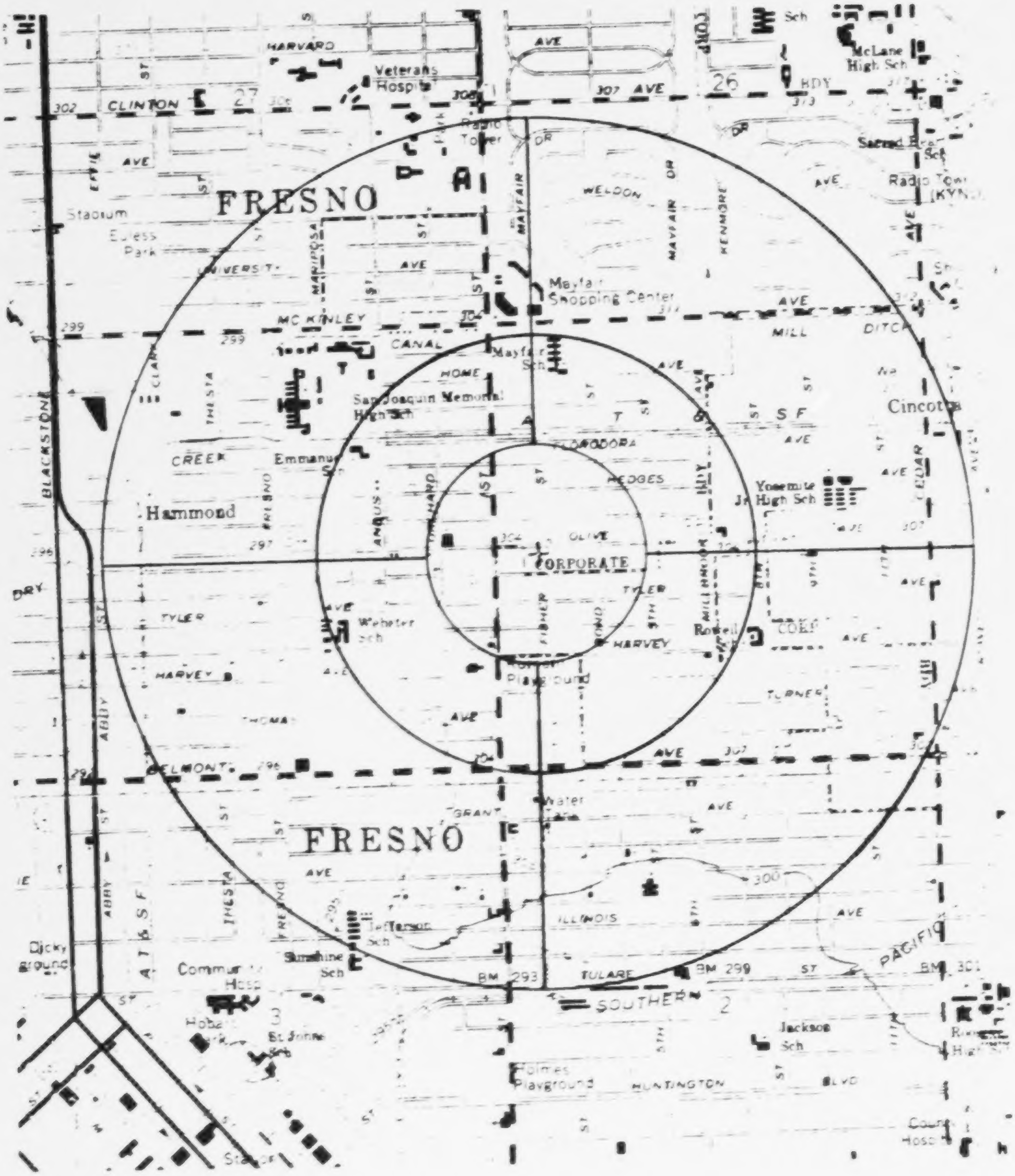
Localized sources, within 200 ft of monitor -

Source	Distance	Description
Fisher Street	45 ft	200 ADT, clean, curbed
Olive Street	75 ft	6800 ADT, clean, curbed

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	128.1	57
1976	128.9	59
1975[a]	111.0	50

[a] May not represent year's average.


HARVARD
Veterans Hospital
CLINTON
AVE
27
26
McLane High Sch
Radio Tower
Sacred Heart Sch
Radio Tower (KYNO)
FRESNO
Stadium
Euless Park
UNIVERSITY
MARIPOSA
WELDON
MAYFAIR
KENMORE
Mayfair Shopping Center
MC KINLEY
CANAL
MILL
DITCH
Mayfair Sch
HOME
San Joaquin Memorial High Sch
Cincotta
CREEK
Emmanuel Sch
FLORADORA
HEDGES
Yosemite Jr High Sch
Hammond
BLACKSTONE
ANGUS
OLIVE
CORPORATE
TYLER
HARVEY
Roeding
Webster Sch
Playground
THOMAS
TURNER
BELMONT
GRANT
Water Tank
FRESNO
ILLINOIS
Jefferson Sch
Sunshine Sch
Community Hosp
TULARE
BM 293
BM 299
BM 301
SOUTHERN
PACIFIC
Jackson Sch
Holmes Playground
HUNTINGTON
BLVD
ABBY
THESTA
CEDAR

One mile radius around Olive Street, Fresno site.

Viewed to the west-southwest.

Viewed to the south-southwest.

Sampler at Olive Street, Fresno.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates x	UTM coordinates y
1	Zacky Farms	30	2.3	4	249.3	4070.2
2	Ranchers Cotton Oil	131	3.8	3	254.2	4065.4
3	Craycroft Brick	248	4.1	4	246.3	4070.4
4	Wingate Co.	26	4.2	3	255.7	4065.2
5	Wilbur/Ellis	108	4.4	3	254.0	4064.4
6	Producers Cotton Oil	155	4.8	3	255.0	4064.0
7	River Rock Products	109	5.0	4	245.9	4075.8

AREA SOURCE SUMMARY

Site: Olive Street, Fresno

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.2	0.1	0.1	0.1	0.1	0.4	0.5	0.4	0.5	2.4
Comm/Ind fuel					0.1	0.1	0.2	0.1	0.1	0.2	0.8
Incinerators		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	1.0
Rail/Air			0.2			0.2	0.3			0.3	1.0
Auto exhaust	6.5×10^7 VMT	3.6	0.3	0.1	1.8	2.1	4.4	6.0	9.2	8.0	35.5
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards	22 ac		0.6			0.6	0.9			0.6	2.9
Clean streets	6.5×10^7 VMT	31.8	2.9	1.0	16.6	18.4	39.3	53.4	82.7	72.3	318.4
Comm streets											
Unpaved roads	6.9×10^2 VMT						1.2				1.2
Cleared areas	31.8 ac	0.1			0.1		2.0	0.1	0.1	3.8	6.2
Construction	4 ac					21.6			21.6		43.2
Agriculture											
Storage areas	0.5 ac									0.1	0.1
Unpaved pkg lots	1.0×10^4 VMT	0.3		1.5	0.1	0.3	1.0	2.7	0.6	1.8	8.3

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	3.9	5.7	31.1	40.7
IND PROCESSES				
FUGITIVE DUST	32.2	63.7	284.2	380.1
Total	36.1	69.4	315.3	420.8

DESCRIPTION OF SITE

SAROAD code - NA

Location - Geography Building, Cal State, Fresno

UTM coordinates - 255.3, 4077.5

Monitor height - 35 ft, on roof of building

Topography - No special terrain

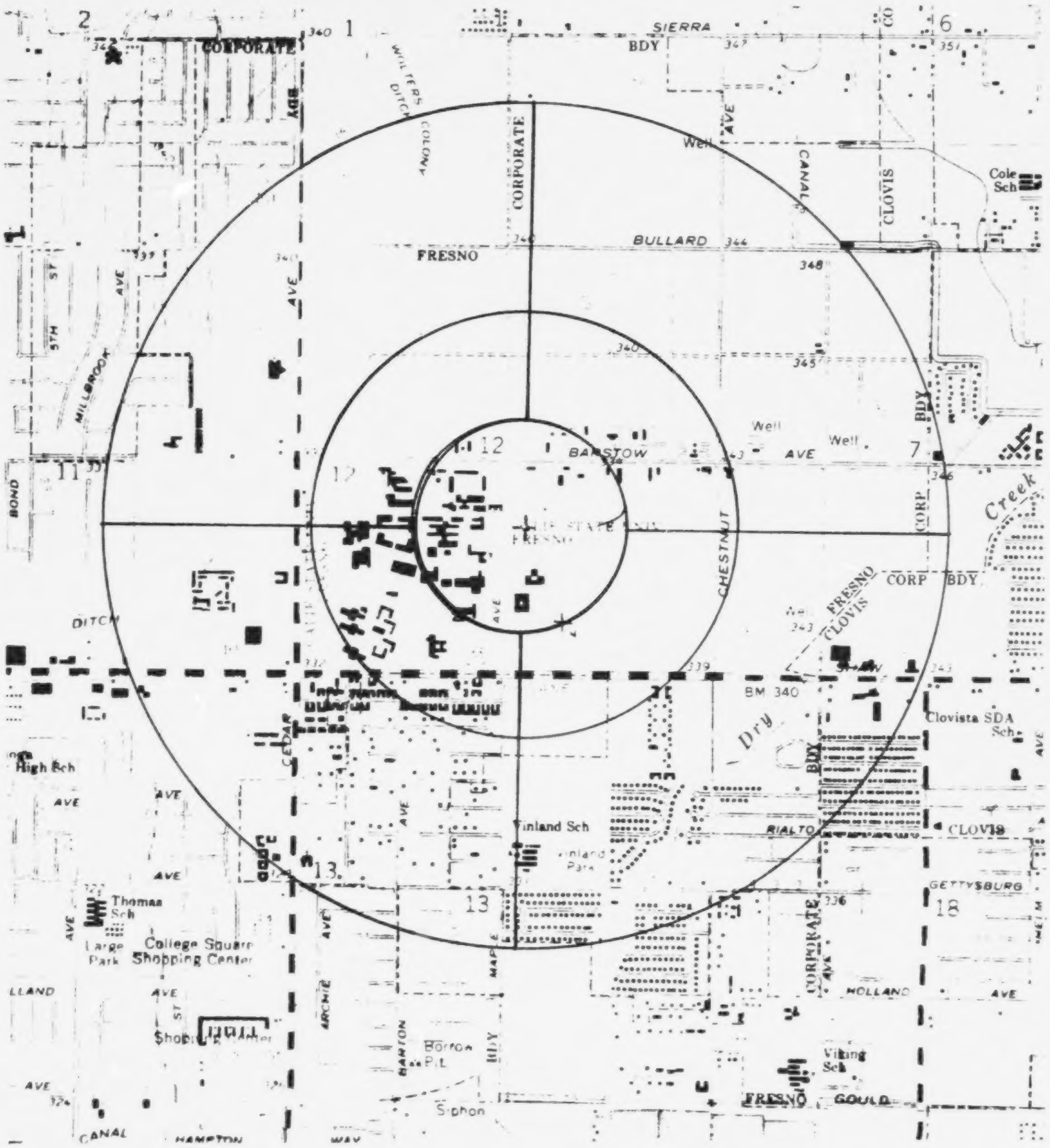
Localized sources, within 200 ft of monitor -

Source	Distance	Description
Service drive	125 ft	1000 ADT, clean, curbed

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977[a]	109.1	47
1976	106.1	56
1975	99.1	60
1974[a]	59.2	27
1973[a]	76.4	33

[a] May not represent year's average.



SIERRA
BDY
CORPORATE
BDY
WILTERS DITCH
COLONY
CORPORATE
CANAL
CLOVIS
Cole Sch
BULLARD
FRESNO
AVE
5TH ST
MILLBROOK
BOND
Well
BARSTOW
AVE
CORP BDY
Creek
CHESTNUT
FRESNO CLOVIS
DITCH
BM 340
Dry
Clovista SDA Sch
High Sch
CEDAR
Vinland Sch
Vinland Park
RIALTO
CLOVIS
GETTYSBURG
Thomas Sch
Large Park
College Square Shopping Center
LLAND
ARCHIE
MAPLE
CORPORATE
HOLLAND
Borrow Pit
BARTON
Viking Sch
FRESNO
GOULD
Siphon
CANAL
HAMPTON
WAY

One mile radius around Geography Building, Cal State, Fresno site.

Viewed to the east.

Viewed to the north.

Sampler at Geography Building, Cal State, Fresno.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates	
					x	y

No point sources within 5 miles.

AREA SOURCE SUMMARY

Site: Geography Building, Cal State, Fresno

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.2		0.4	0.2		0.2	1.2	0.2	0.2	2.6
Comm/Ind fuel		0.4			0.1	0.4				0.1	1.0
Incinerators		0.3			0.3	0.1			0.1	0.1	0.9
Rail/Air											
Auto exhaust	4.0×10^7 VMT	0.8	0.5	2.2	2.9	0.4	2.1	4.6	5.7	2.4	21.6
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards											
Clean streets	4.0×10^7 VMT	7.7	4.8	20.2	26.5	3.9	19.0	41.6	51.5	21.8	197.0
Comm streets											
Unpaved roads	7.3×10^2 VMT							1.2			1.2
Cleared areas	2.1 ac							0.4			0.4
Construction	49 ac	10.8						70.2	81.0	108.0	270.0
Agriculture	603 ac	33.0	23.4	0.6		5.0	41.4	12.4		19.5	135.3
Storage areas											
Unpaved pkg lots	4.1×10^2 VMT	0.1	0.2								0.3

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	1.7	7.5	16.9	26.1
IND PROCESSES				
FUGITIVE DUST	51.6	84.6	468.0	604.2
Total	53.3	92.1	484.9	630.3

DESCRIPTION OF SITE

SAROAD code - 052820002I01

Location - Five Points/Calflax

UTM coordinates - 759.9, 4025.5

Monitor height - 12 ft, on roof of rain shelter

Topography - No special terrain

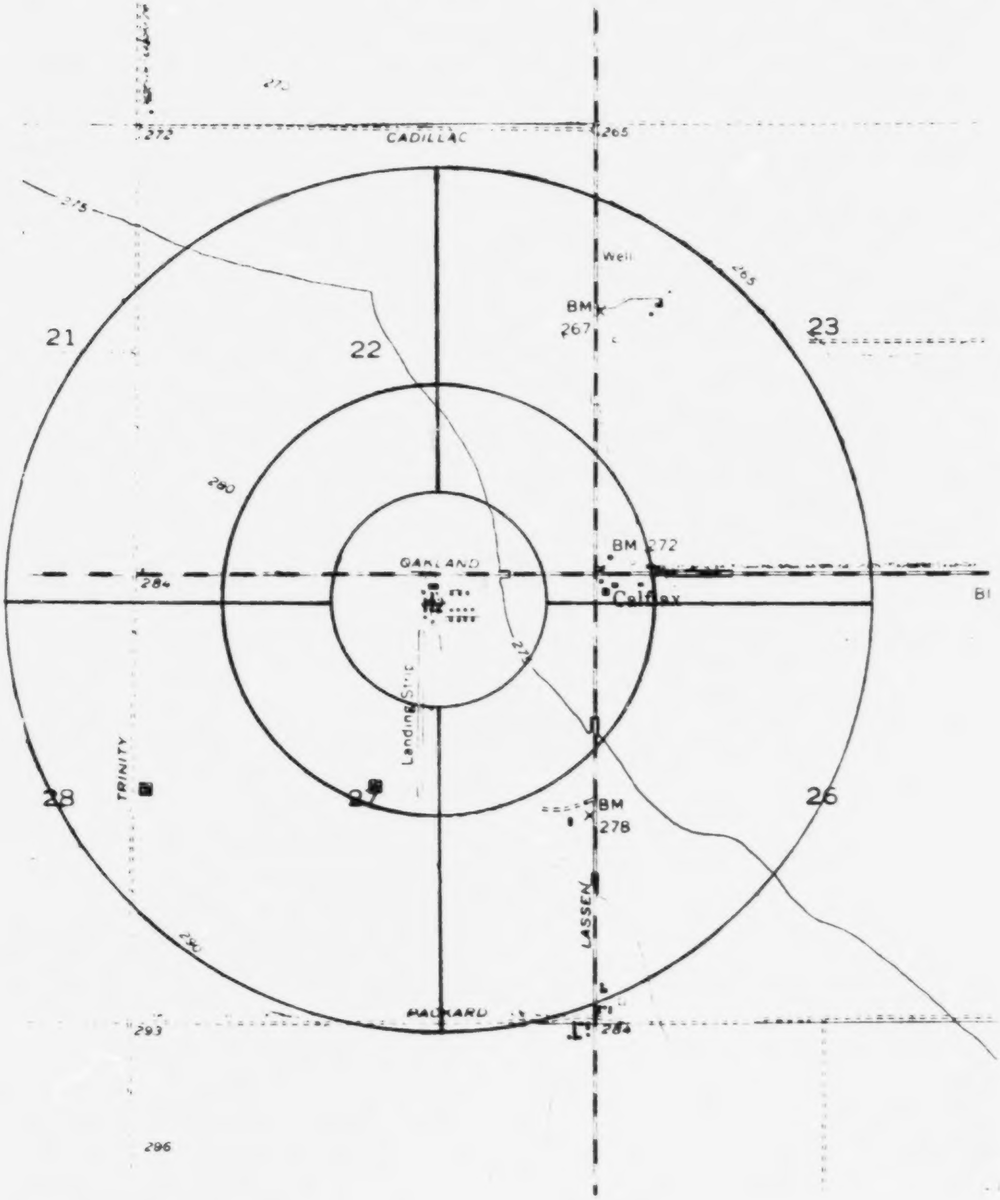
Localized sources, within 200 ft of monitor -

Source	Distance	Description
Parking lot	30 ft	unpaved

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	106.6	54
1976	93.8	60
1975	82.9	59
1974[a]	71.3	27
1973	63.7	46

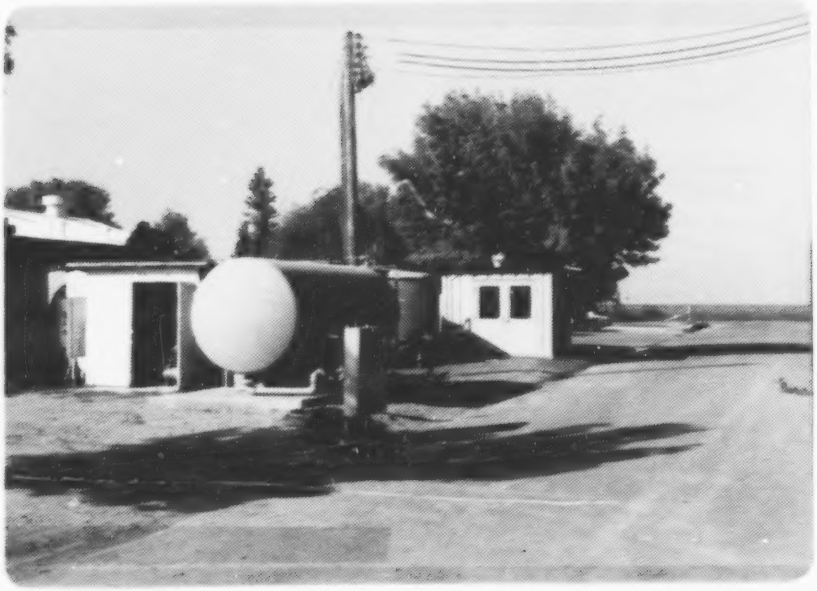
[a] May not represent year's average.



270
272
CADILLAC
265
275
Well
265
BM
267
21
22
23
280
BM 272
OAKLAND
284
Calflax
BI
275
Landing Strip
TRINITY
28
27
26
BM
278
LASSEN
290
PACKARD
293
284
296

One mile radius around Five Points/Calflax site.

Viewed to the south.



Viewed to the north-northwest.

Sampler at Five Points/Calflax.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates	
					x	y

No point sources listed within 5 mi
of sampler.

AREA SOURCE SUMMARY

Site: Five Points/Calflax

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel											
Comm/Ind fuel											
Incinerators											
Rail/Air											
Auto exhaust	$1.8x10^6$ VMT	0.1	0.2	0.1			0.3	0.2		0.1	1.0
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards											
Clean streets	$1.8x10^6$ VMT	0.6	1.7	1.3		0.3	2.5	2.0		0.5	8.9
Comm streets											
Unpaved roads	3559 VMT							0.9	4.4	3.7	9.0
Cleared areas											
Construction											
Agriculture	1960 ac	21.6	17.1	17.1	17.1	17.1	70.3	70.3	70.3	70.3	371.2
Storage areas											
Unpaved pkg lots	864 VMT	0.7									0.7

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	0.1	0.3	0.6	1.0
IND PROCESSES				
FUGITIVE DUST	22.9	71.7	295.2	389.8
Total	23.0	72.0	295.8	390.8

DESCRIPTION OF SITE

SAROAD code - NA

Location - W. Cherry Lane, Coalinga

UTM coordinates - 737.8, 4003.5

Monitor height - 12 ft, on roof of building

Topography - No special terrain

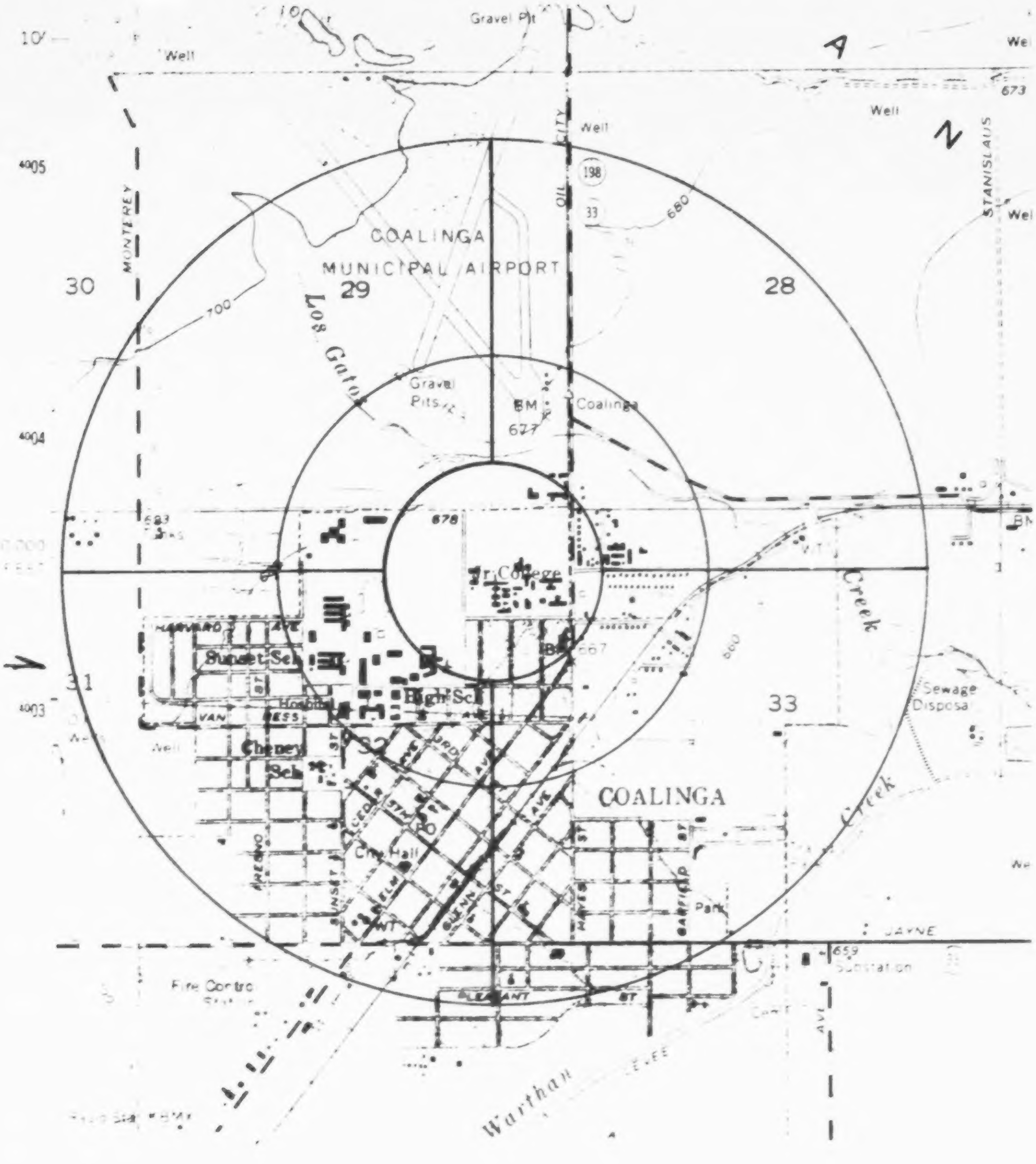
Localized sources, with 200 ft of monitor -

Source	Distance	Description
None		

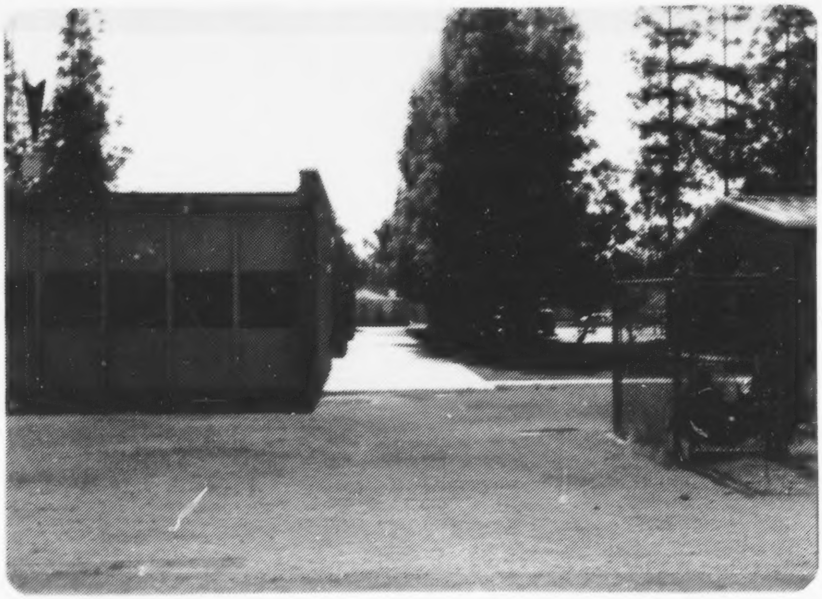
Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	81.8	55
1976	87.6	57
1975[a]	129.6	14
1974[a]	53.1	13
1973[a]	69.7	30

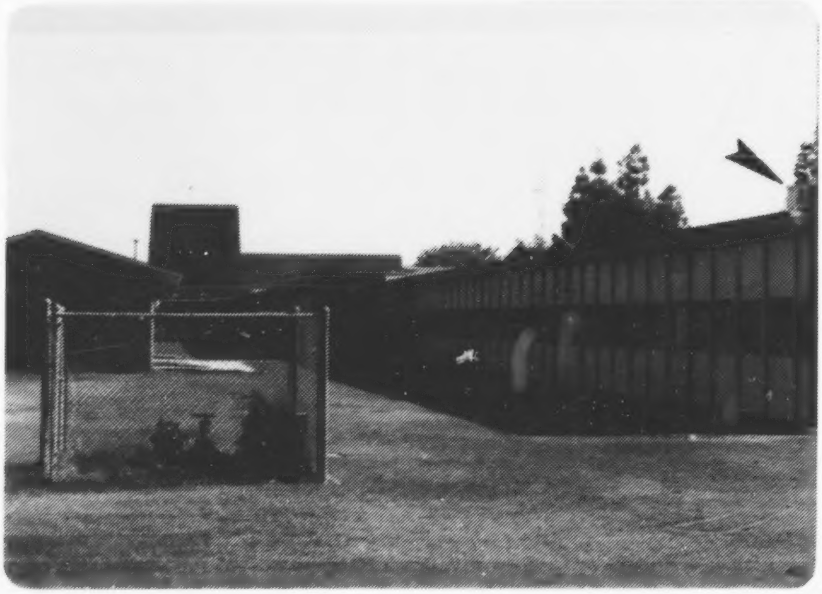
[a] May not represent year's average.


COALINGA
MUNICIPAL AIRPORT
30
29
28
31
33
Los Gatos
Creek
Gravel Pits
BM 677
Coalinga
Jr. College
High Sch
Sunset Sch
Cheney Sch
Hospital
HARVARD AVE
VAN NESS
City Hall
COALINGA
Park
JAYNE
Substation
Sewage Disposal
Fire Control Station
Warthan
MONTEREY
STANISLAUS
OIL CITY
198
33
Gravel Pit
Well
680
700
678
667
659
673
683
A
N
4005
4004
4003

One mile radius around W. Cherry Lane, Coalinga site.



Viewed to the south.



Viewed to the east.

Sampler at W. Cherry Lane, Coalinga.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	quadrant	UTM coordinates x	y
1	L. D. Folsom, Inc.	46	1.4	1	736.7	4005.5
2	Shell Oil	75	2.0	4	735.0	4002.0

AREA SOURCE SUMMARY

Site: W. Cherry Lane, Coalinga

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.1		0.1	0.1				0.5	0.2	1.0
Comm/Ind fuel		0.1			0.1				0.1		0.3
Incinerators		0.1			0.1				0.1		0.3
Rail/Air				0.1			0.1		0.2	0.1	0.5
Auto exhaust	1.6×10^6 VMT	0.1	0.1				0.1	0.2	0.3		0.8
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards											
Clean streets	1.6×10^6 VMT	0.6	0.7	0.4	0.2		0.9	1.8	2.8	0.2	7.6
Comm streets											
Unpaved roads											
Cleared areas	51.3 ac			8.7	0.1	0.1		1.2	9.7	9.0	28.8
Construction											
Agriculture	271 ac		5.8				139.2	3.5		8.7	157.2
Storage areas	14 ac								10.2		10.2
Unpaved pkg lots	2.2×10^3 VMT		1.8		0.1						1.9

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	0.4	0.6	1.9	2.9
IND PROCESSES				
FUGITIVE DUST	0.6	17.9	187.2	205.7
Total	1.0	18.5	189.1	208.6

DESCRIPTION OF SITE

SAROAD code - 05458000I01

Location - 240 E. 15th Street, Merced

UTM coordinates - 724.0, 4130.3

Monitor height - 12 ft, on roof of building

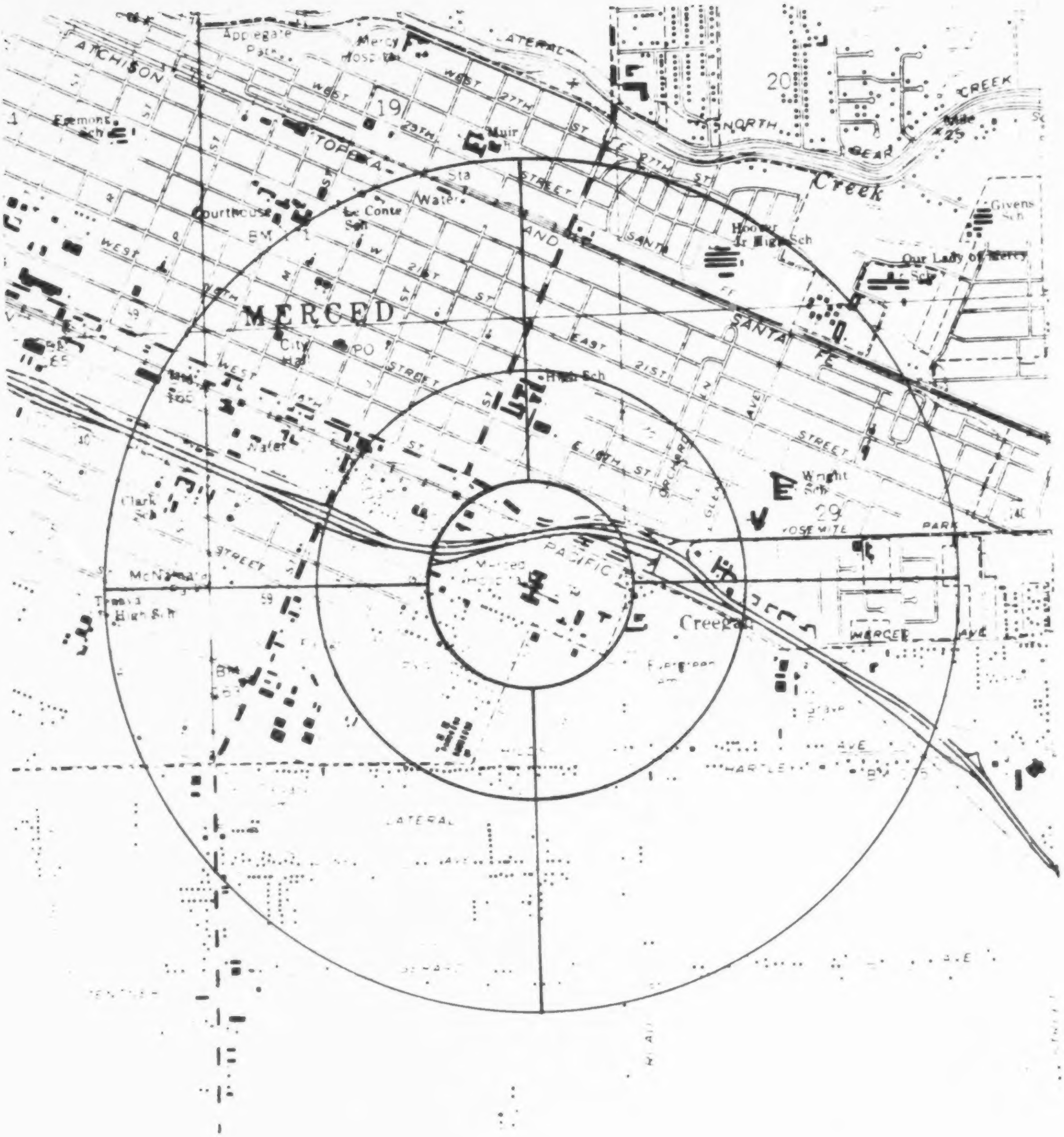
Topography - No special terrain

Localized sources, within 200 ft of monitor -

Source	Distance	Description
Service drive	180 ft	1000 ADT, clean, curbed

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	84.7	49
1976	85.3	54
1975	75.7	50
1974	69.4	55
1973	79.3	57



MERCED
ATCHISON
TOPEKA
AND
SANTA FE
PACIFIC
Applegate Park
Mercy Hospital
Fremont Sch
Muir Sch
Courthouse
Le Conte Sch
City Hall
PO
High Sch
Hoover Jr High Sch
Givens Sch
Our Lady of Mercy Sch
Wright Sch
Clark Sch
McNamara
Tenaya High Sch
Merced
Creek
Evergreen
NORTH BEAR CREEK
Creek
WEST 27TH
WEST 23RD
WEST 21ST
WEST 18TH
WEST 14TH
EAST 21ST
E 16TH ST
E 27TH ST
YOSEMITE
PARK
MERCED AVE
HARTLEY
LATERAL
19
20
29

One mile radius around 240 E. 15th Street, Merced site.

Viewed to the northeast.

Viewed to the southeast.

Sampler at 240 E. 15th Street, Merced.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates x	UTM coordinates y
1	Ragu Foods	28	2.3	4	720.8	4132.2

AREA SOURCE SUMMARY

Site: 240 E. 15th Street, Merced

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.2	0.5		0.3	0.5	0.7	0.2	0.2	0.6	3.2
Comm/Ind fuel		0.1				0.1				0.2	0.4
Incinerators		0.2				0.1				0.1	0.4
Rail/Air		0.1				0.2	0.2	0.1		0.3	0.9
Auto exhaust	4.0×10^7 VMT	3.9	1.4	0.1	0.3	3.4	3.5	3.0	0.3	7.4	23.3
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards											
Clean streets	3.9×10^7 VMT	29.1	12.2	1.0	2.4	25.9	30.4	26.4	3.0	58.6	189.0
Comm streets	1.6×10^6 VMT	12.0				7.5				13.5	33.0
Unpaved roads					0.6				0.2		0.8
Cleared areas	10.7 ac						17.5				17.5
Construction	4 ac			0.5				17.8	5.1		23.4
Agriculture	138 ac	0.2						11.7	0.7		12.6
Storage areas	12 ac										
Unpaved pkg lots	4.0×10^3 VMT	0.1				0.9		0.9	0.3	1.2	3.4

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	4.5	6.9	16.8	28.2
IND PROCESSES				
FUGITIVE DUST	41.4	51.0	187.3	279.7
Total	45.9	57.9	204.1	307.9

DESCRIPTION OF SITE

SAROAD code - 054720001F01

Location - 1024 J Street, Modesto

UTM coordinates - 676.6, 4167.7

Monitor height - 55 ft, on roof of building

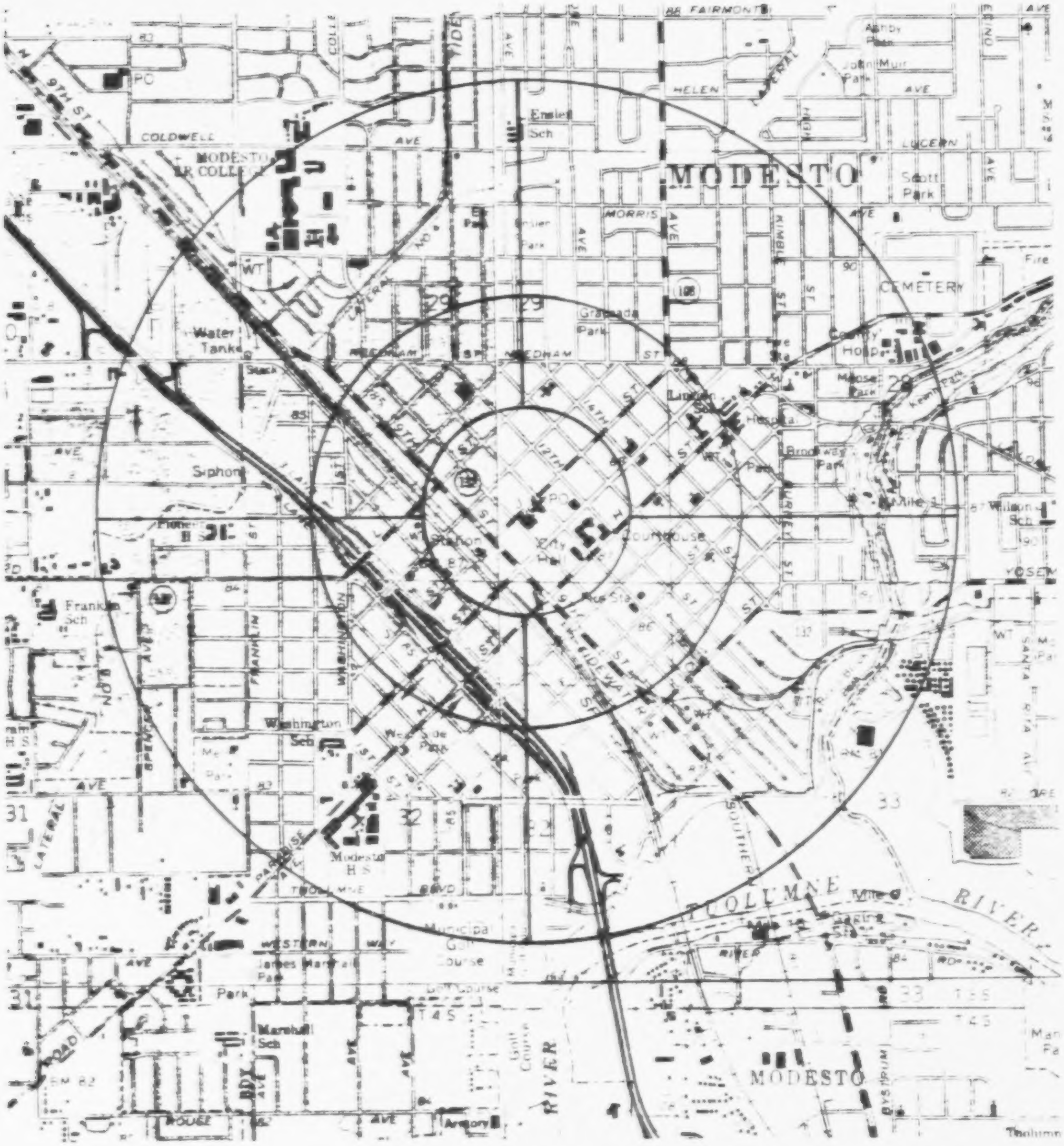
Topography - Elevated receptor

Localized sources, within 200 ft of monitor -

Source	Distance	Description
J Street	60 ft	10,900 ADT, clean, curbed
11th Street	108 ft	3700 ADT, clean, curbed

Air quality data -

Year	Annual geometric mean, $\mu g/m^3$	No. of samples
1977	101.1	60
1976	106.3	61
1975	97.6	59
1974	107.8	55
1973	99.3	42


MODESTO
COLDWELL
AVE
HELEN
LUCERN
MORRIS
NEEDHAM
9TH ST
Scott Park
CEMETERY
Granada Park
Water Tank
Siphon
Courthouse
City Hall
Franklin Sch
Washington Sch
West Side Park
Modesto H S
TUOLUMNE RIVER
Municipal Golf Course
James Marshall Park
Marshall Sch
Armory
MODESTO JR COLLEGE
Enslen Sch
John Muir Park
Roosevelt Jr Sch
Hospital
Broadway Park
Moose Park
County Hosp
FAIRMONT
YOSEMITE
WESTERN
T 4 S
29
31
32
33

One mile radius around 1024 J Street, Modesto site.

Viewed to the southeast.

Viewed to the southwest.

Sampler at 1024 J Street, Modesto.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates x	UTM coordinates y
1	J. S. West Milling	77	.33	3	676.8	4167.2
2	FMC Corp.	91	1.2	4	675.1	4168.9
3	Gallo Glass	176	1.5	2	678.7	4166.4

AREA SOURCE SUMMARY

Site: 1024 J Street, Modesto

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.2	0.2	0.2	0.2	0.2	0.3	0.1	0.3	0.2	1.9
Comm/Ind fuel		0.1					0.1	0.1	0.1	0.2	0.6
Incinerators											
Rail/Air				0.3		0.3		1.8		0.6	3.0
Auto exhaust	8.2×10^7 VMT	6.7	4.4	2.3	4.1	1.5	7.2	8.6	3.2	6.5	44.5
INDUS PROCESSES:											
Ind processes		13.0						12.0		11.0	36.0
FUGITIVE DUST:											
Railroad yards								1.9			1.9
Clean streets	8.2×10^7 VMT	58.8	39.0	20.6	36.3	13.3	63.0	75.6	28.5	56.9	392.0
Comm streets											
Unpaved roads											
Cleared areas	8.0 ac	0.2						1.5			1.7
Construction	0.5 ac									1.1	1.1
Agriculture											
Storage areas	1.2 ac	0.1						0.3			0.4
Unpaved pkg lots	6.1×10^3 VMT	0.6		0.9	0.1	0.1		3.0		0.4	5.1

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	7.0	13.7	29.3	50.0
IND PROCESSES	13.0		23.0	36.0
FUGITIVE DUST	59.7	110.3	232.2	402.2
Total	79.7	124.0	284.5	488.2

DESCRIPTION OF SITE

SAROAD code - 058040002F01

Location - E. Hazelton Avenue, Stockton

UTM coordinates - 652.2, 4201.6

Monitor height - 20 ft, on roof of building

Topography - No special terrain

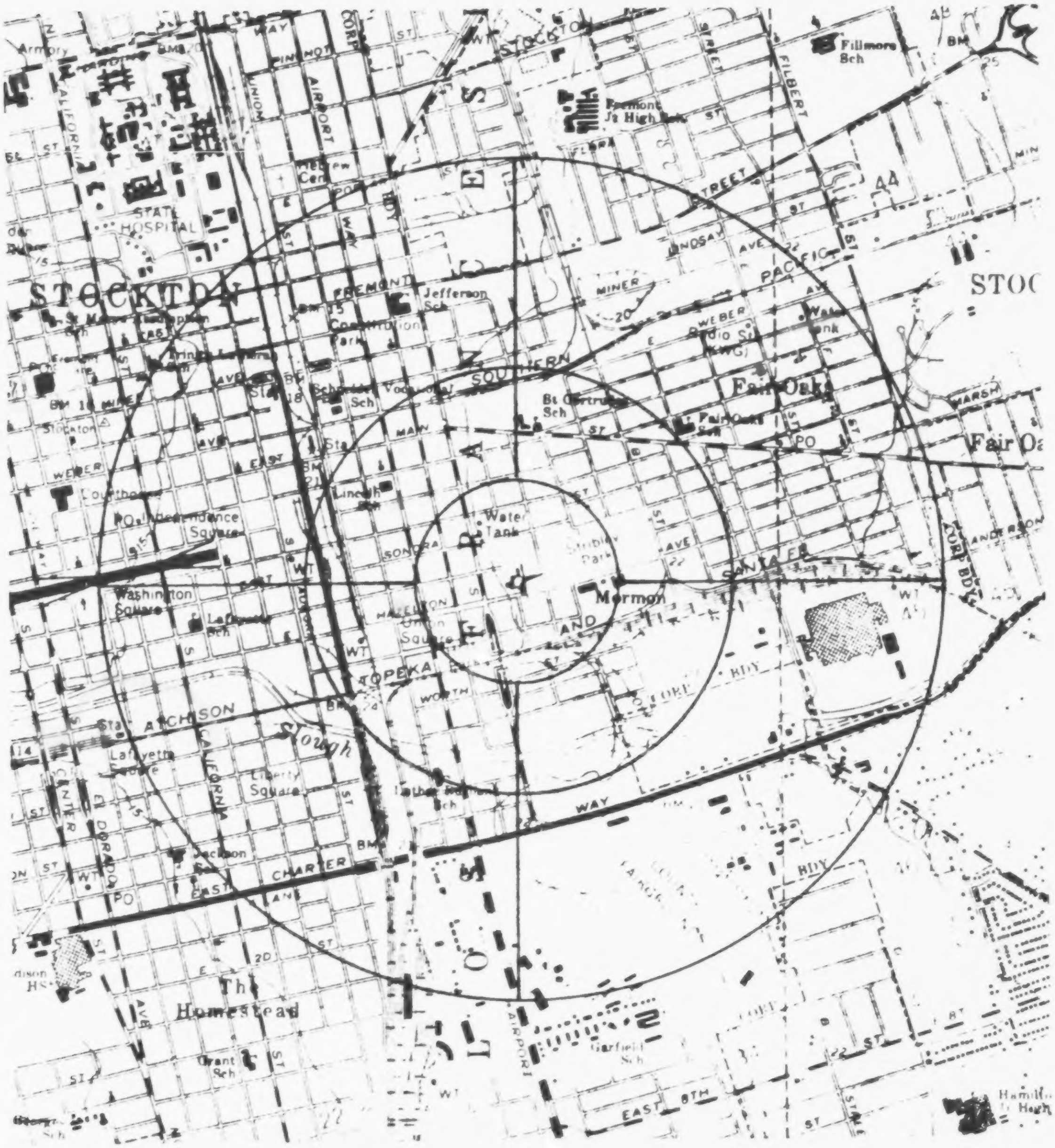
Localized sources, within 200 ft of monitor -

Source	Distance	Description
Hazelton Street	165 ft	5700 ADT, clean, curbed

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	52.2	48
1976[a]	55.7	30
1975	81.5	41
1974	83.9	55
1973	83.3	52

[a] May not represent year's average.



One mile radius around E. Hazelton Avenue, Stockton site.

Viewed to the west-southwest.

Viewed to the northeast.

Sampler at E. Hazelton Avenue, Stockton.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates x	UTM coordinates y
1	American Forest Products	144	2.2	1	650.7	4204.9
2	James Allan and Sons	30	2.5	2	655.7	4199.6
3	Stockton Elevators	417	2.7	4	647.9	4201.3
4	California Cedar Products	99	3.0	4	647.5	4200.8
5	Port of Stockton	629	3.2	4	647.1	4201.5
6	John-Manville Products	55	3.4	3	653.2	4196.2

AREA SOURCE SUMMARY

Site: E. Hazelton Avenue, Stockton

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.3	0.3	0.1	0.2	0.2	0.6		0.6	0.6	2.9
Comm/Ind fuel		0.2	0.1	0.1	0.3	0.3	0.1	0.6	0.6	0.6	2.9
Incinerators											
Rail/Air		0.1		0.3	0.3	0.1	0.9		1.0	0.3	3.0
Auto exhaust	$6.7\text{x}10^7$ VMT	2.9	0.8	0.9	1.4	3.6	2.9	6.6	8.3	9.2	36.6
INDUS PROCESSES:											
Ind processes							2.0	6.0	21.0	25.0	54.0
FUGITIVE DUST:											
Railroad yards	66 ac	0.5		1.2	0.8	0.5	2.2	0.1	2.7	0.5	8.5
Clean streets	$6.7\text{x}10^7$ VMT	25.1	6.6	8.1	12.0	31.7	25.5	58.2	73.1	80.5	320.8
Comm streets											
Unpaved roads											
Cleared areas	5.0 ac					0.2	0.5		0.2		0.9
Construction	3.5 ac				3.3					8.8	12.1
Agriculture											
Storage areas	6.5 ac	0.1		0.7			0.7				1.5
Unpaved pkg lots	$6.0\text{x}10^3$ VMT	0.3					1.6	1.2	1.6	0.4	5.1

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	3.5	9.0	32.9	45.4
IND PROCESSES			54.0	54.0
FUGITIVE DUST	26.0	65.1	257.8	348.9
Total	29.5	74.1	344.7	448.3

DESCRIPTION OF SITE

SAROAD code - 056580003F01

Location - 1025 P Street, Sacramento

UTM coordinates - 631.2, 4270.4

Monitor height - 85 ft, on roof of building

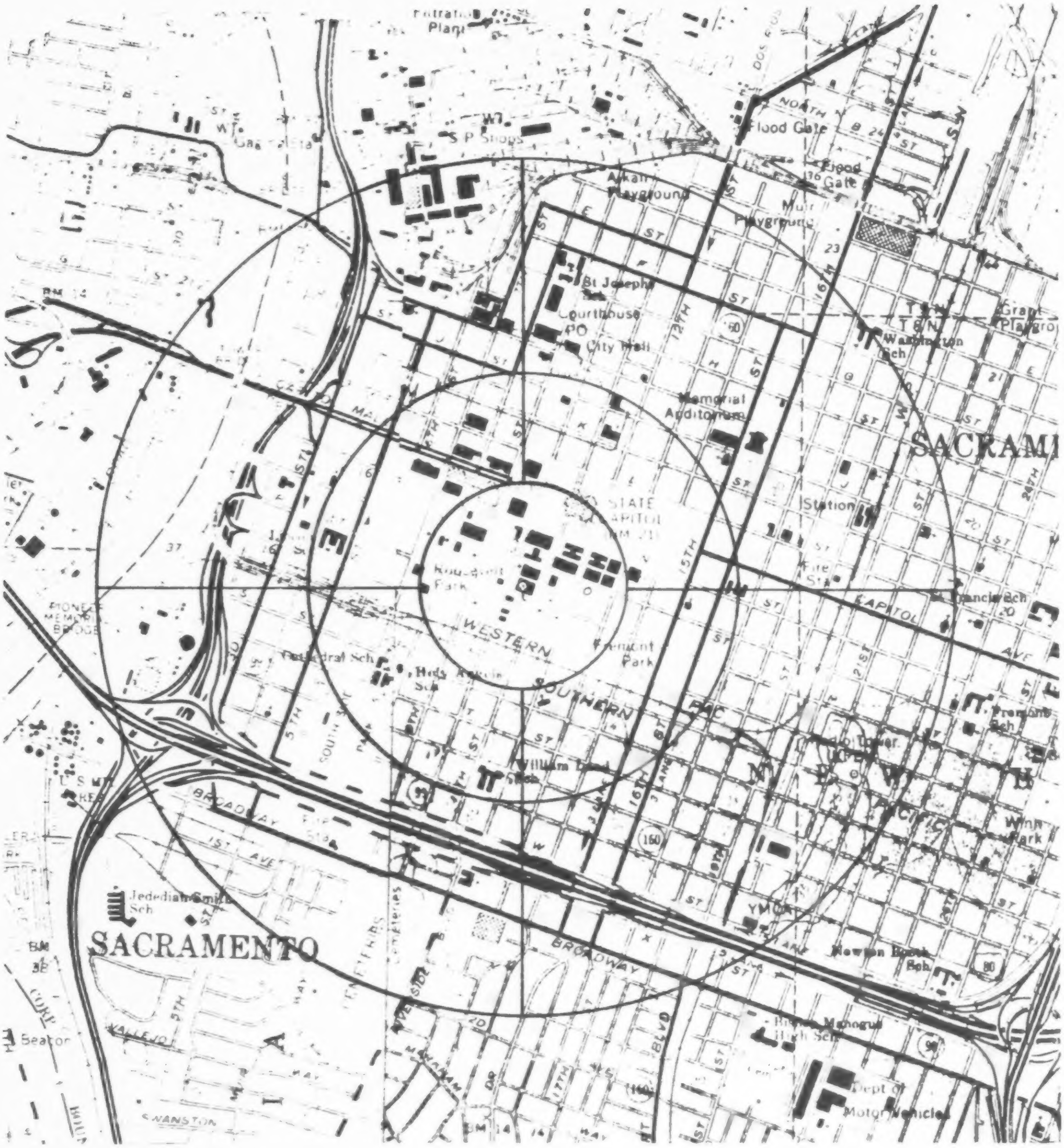
Topography - Elevated receptor

Localized sources, within 200 ft of monitor -

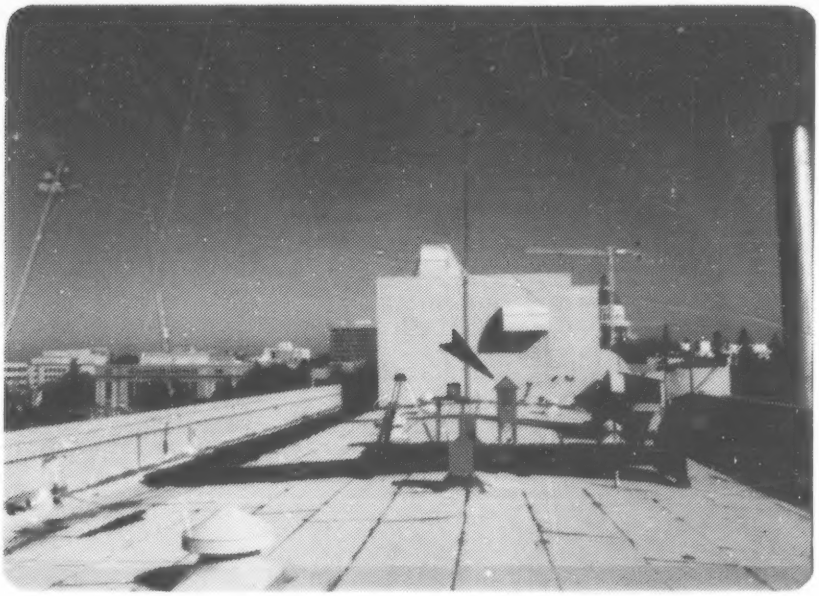
Source	Distance	Description
10th Street	160 ft	8300 ADT, clean, curbed
P Street	60 ft	7300 ADT, clean, curbed

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	63.3	56
1976	68.8	60
1975	59.9	59
1974	67.1	58
1973	62.0	50


Filtration Plant
S P Shops
Alkali Playground
Flood Gate
Muir Playground
St Joseph Sch
Courthouse
PO
City Hall
Memorial Auditorium
Washington Sch
SACRAMENTO
Station
Fire Sta
STATE CAPITOL
Roosevelt Park
CAPITOL AVE
WESTERN
SOUTHERN
PACIFIC
Fremont Park
Cathedral Sch
Holy Angels Sch
William Land Sch
Fremont Sch
Winn Park
BROADWAY
YMCA
Newton Booth Sch
Bishop Manogue High Sch
Dept of Motor Vehicles
Jedediah Smith Sch
SACRAMENTO

One mile radius around 1025 P Street, Sacramento site.



Viewed to the north-northeast.

Viewed to the east.

Sampler at 1025 P Street, Sacramento.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates x	UTM coordinates y
1	Setzer Forest Products	43	1.0	4	629.8	4269.5
2	CARADCO Window and Door	50	1.1	4	629.5	4270.0
3	McKuen Moulding	25	1.1	3	629.9	4269.1
4	California Dehydrating	79	1.6	4	629.1	4271.9
5	Rice Mill Products	58	1.7	4	628.5	4270.7
6	Rice Growers Assoc.	278	1.8	4	628.5	4271.5
7	Sacto-Yolo Port Terminal	230	2.7	4	627.0	4269.4
8	Farmers Rice Coop	82	3.1	4	626.7	4268.2
9	Alpine Lumber	25	3.2	2	635.0	4274.0
10	Cargill	170	3.2	4	626.2	4269.2
11	Taymac, Inc.	27	3.9	2	637.1	4268.2
12	Dorris Lumber	30	4.4	2	637.6	4267.2
13	Granite Construction	64	5.0	2	638.8	4266.9

AREA SOURCE SUMMARY

Site: 1025 P Street, Sacramento

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.1	0.1	0.1	0.1	0.1	0.5	0.5	0.5		2.0
Comm/Ind fuel		0.4	0.2	0.1	0.1	0.3	0.2	0.1	0.2	0.6	2.2
Incinerators										0.4	0.4
Rail/Air		0.1		0.1	0.2	0.1	0.1	0.2	0.1	1.6	2.5
Auto exhaust	1.5×10^8 VMT	3.9	2.8	3.9	2.2	4.2	13.5	17.5	20.8	14.9	83.7
INDUS PROCESSES:											
Ind processes					4.0					33.0	37.0
FUGITIVE DUST:											
Railroad yards											
Clean streets	1.5×10^8 VMT	33.8	24.1	33.0	18.5	35.8	115.9	149.6	178.2	127.3	716.2
Comm streets											
Unpaved roads											
Cleared areas											
Construction	9.0 ac			2.2			11.0			26.3	39.2
Agriculture											
Storage areas											
Unpaved pkg lots	7.8×10^3 VMT			0.3	3.3			1.3	0.3	1.0	6.2

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	4.5	14.6	71.7	90.8
IND PROCESSES		4.0	33.0	37.0
FUGITIVE DUST	33.8	117.2	610.9	761.9
Total	38.3	135.8	715.6	889.7

DESCRIPTION OF SITE

SAROAD code - NA

Location - 117 W. Main Street, Woodland

UTM coordinates - 605.3, 4281.3

Monitor height - 20 ft, on roof of building

Topography - No special terrain

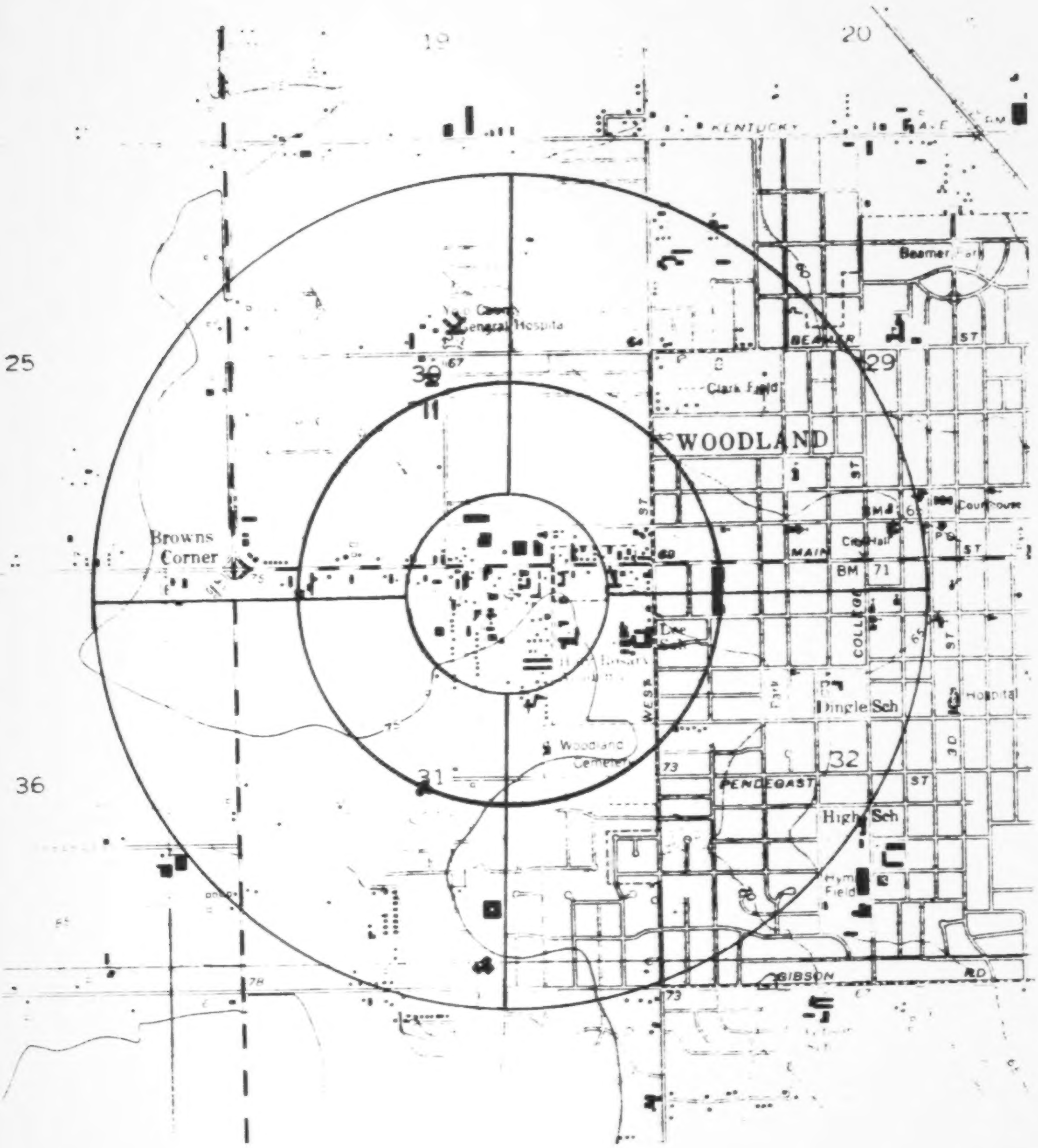
Localized sources, within 200 ft of monitor -

Source	Distance	Description
None		

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	62.3	58
1976	75.0	60
1975[a]	83.4	13

[a] May not represent year's average.


19
20
25
36
KENTUCKY
Beamer Park
BEAMER
ST
29
30
General Hospital
Clark Field
WOODLAND
Courthouse
City Hall
MAIN
ST
BM 71
Browns Corner
COLLEGE
WEST
Hospital
Dingle Sch
Woodland Cemetery
31
32
PENDEGAST
ST
High Sch
Hyman Field
GIBSON
RD
73

One mile radius around 117 W. Main Street, Woodland site.

Viewed to the west.

Viewed to the south.

Sampler at 117 W. Main Street, Woodland.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	quadrant	UTM coordinates x	UTM coordinates y
1	Woodland Warehouses	35	0.93	2	606.8	4281.3
2	Hayrico, Inc.	108	1.3	4	603.3	4280.7
3	Adams Grain	61	1.5	2	607.4	4280.1
4	Pacific International Rice Mills	230	1.7	2	607.3	4283.2
5	Adams Grain	35	2.9	2	610.0	4281.8
6	Amstar Corp.	152	3.4	1	608.5	4285.7

AREA SOURCE SUMMARY

Site: 117 W. Main, Woodland

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.2	0.3	0.3	0.4	0.3	0.5	0.5	0.2	0.2	2.9
Comm/Ind fuel		0.4		0.3						0.3	1.0
Incinerators											
Rail/Air											
Auto exhaust	3.1×10^{7} VMT	2.4	2.0	1.1		0.7	5.7	1.3	1.7	1.9	16.8
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards											
Clean streets	3.1×10^{7} VMT	20.6	17.5	9.8		6.1	49.2	11.1	15.0	16.5	145.8
Comm streets											
Unpaved roads	5.6×10^{3} VMT				0.6				8.7		9.3
Cleared areas	4.3 ac				0.1	0.1					0.2
Construction	16 ac	8.8	11.0	4.4	4.4					11.0	39.6
Agriculture	269 ac				0.4				16.5	10.0	26.9
Storage areas	0.5 ac										
Unpaved pkg lots	1.8×10^{3} VMT	1.3					0.2				1.5

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	3.0	5.4	12.3	20.7
IND PROCESSES				
FUGITIVE DUST	30.7	54.4	138.2	223.3
Total	33.7	59.8	150.5	244.0

DESCRIPTION OF SITE

SAROAD code - NA

Location - California Street, Sutter City

UTM coordinates - 608.2, 4335.3

Monitor height - 18 ft, on roof of building

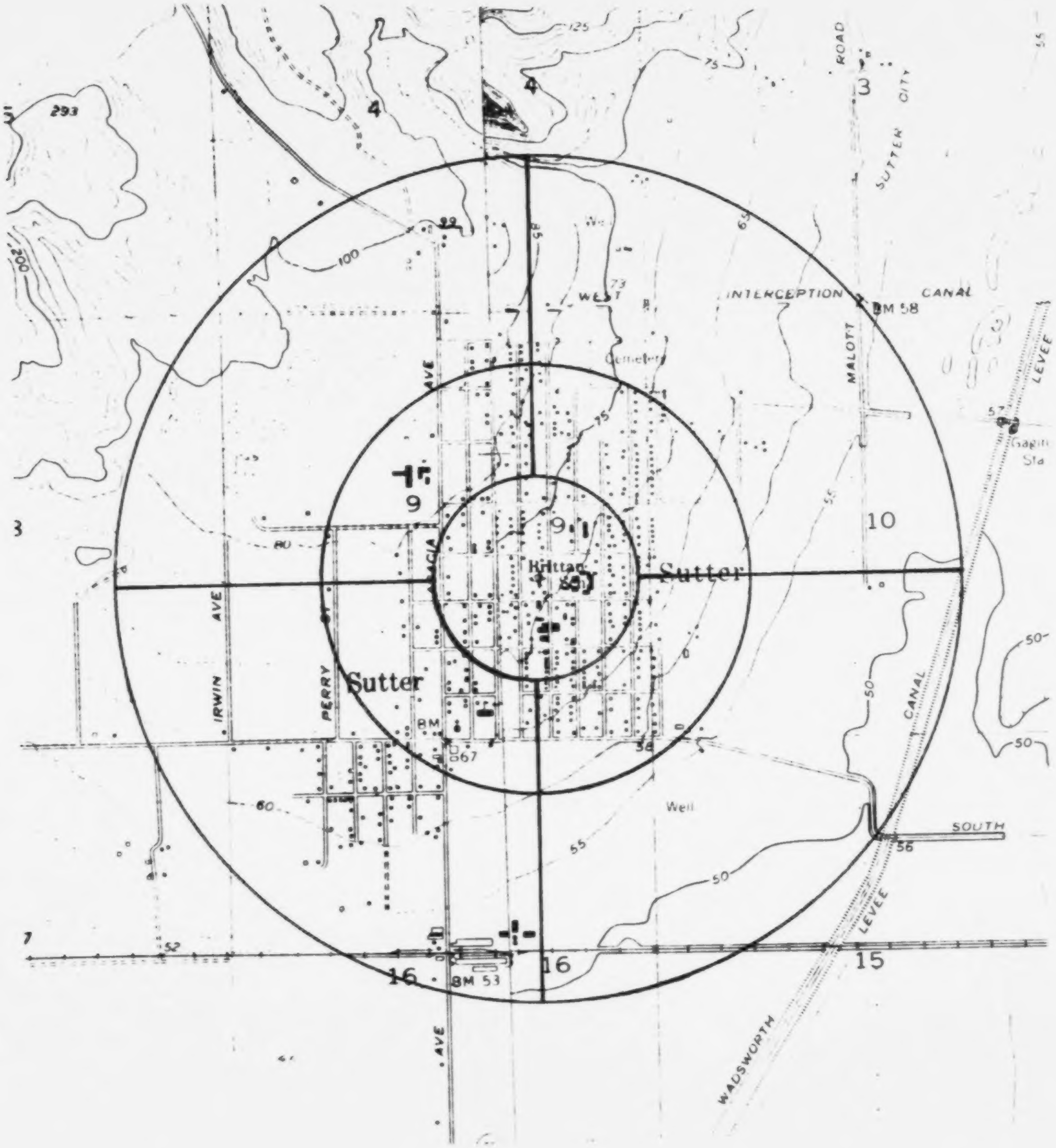
Topography - No special terrain

Localized sources, within 200 ft of monitor -

Source	Distance	Description
California Street	60 ft	1029 ADT, unpaved shoulders

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	69.3	58
1976	88.4	58
1975	63.2	45


293
200
100
125
75
4
4
3
ROAD
SUTTER CITY
65
WEST
INTERCEPTION
CANAL
BM 58
MALOTT
LEVEE
Cemetery
Gagin Sta
9
9
10
3
80
Sutter
Sutter
Kittan
IRWIN AVE
PERRY
ACACIA
AVE
BM
67
55
50
50
50
CANAL
Well
SOUTH
56
60
55
50
LEVEE
7
52
16
BM 53
16
15
AVE
WADSWORTH

One mile radius around Sutter City site.

Viewed to the northwest.

Viewed to the south-southwest.

Sampler at California Street, Sutter City.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates	
					x	y
1	Hi and Dri Warehouse	118	0.93	3	607.8	4333.9
2	Fiddyment Hale Co.	70	3.4	2	613.5	4333.9

AREA SOURCE SUMMARY

Site: California Street, Sutter City

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.3	0.3	0.3	0.3	0.2	0.1		0.2		1.7
Comm/Ind fuel		0.2	0.1	0.1	0.1	0.1			0.1		0.7
Incinerators											
Rail/Air											
Auto exhaust	3.0×10^6 VMT	0.4	0.2	0.1	0.2	0.1	0.2		0.3	0.1	1.6
INDUS PROCESSES:											
Ind processes									9.0		9.0
FUGITIVE DUST:											
Railroad yards											
Clean streets	3.0×10^6 VMT	3.0	1.5	1.0	1.8	1.2	2.0	0.1	2.8	0.4	13.8
Comm streets											
Unpaved roads											
Cleared areas											
Construction	1.0 ac	0.3								0.9	1.2
Agriculture	1047 ac	0.1	1.0	1.8	0.2	0.2	6.2	15.1	3.5	2.7	30.8
Storage areas	2.5 ac					0.1					0.1
Unpaved pkg lots	2.6×10^3 VMT	0.6	0.2	0.1	0.3	0.1	0.1		0.5	0.1	2.0

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	0.9	2.1	2.3	5.3
IND PROCESSES			9.0	9.0
FUGITIVE DUST	4.0	9.5	34.7	47.9
Total	4.9	11.6	46.0	62.2

DESCRIPTION OF SITE

SAROAD code - 054000001I01

Location - 2745 Fir Street, Live Oak

UTM coordinates - 615.3, 4347.9

Monitor height - 16 ft, on roof of fire station

Topography - No special terrain

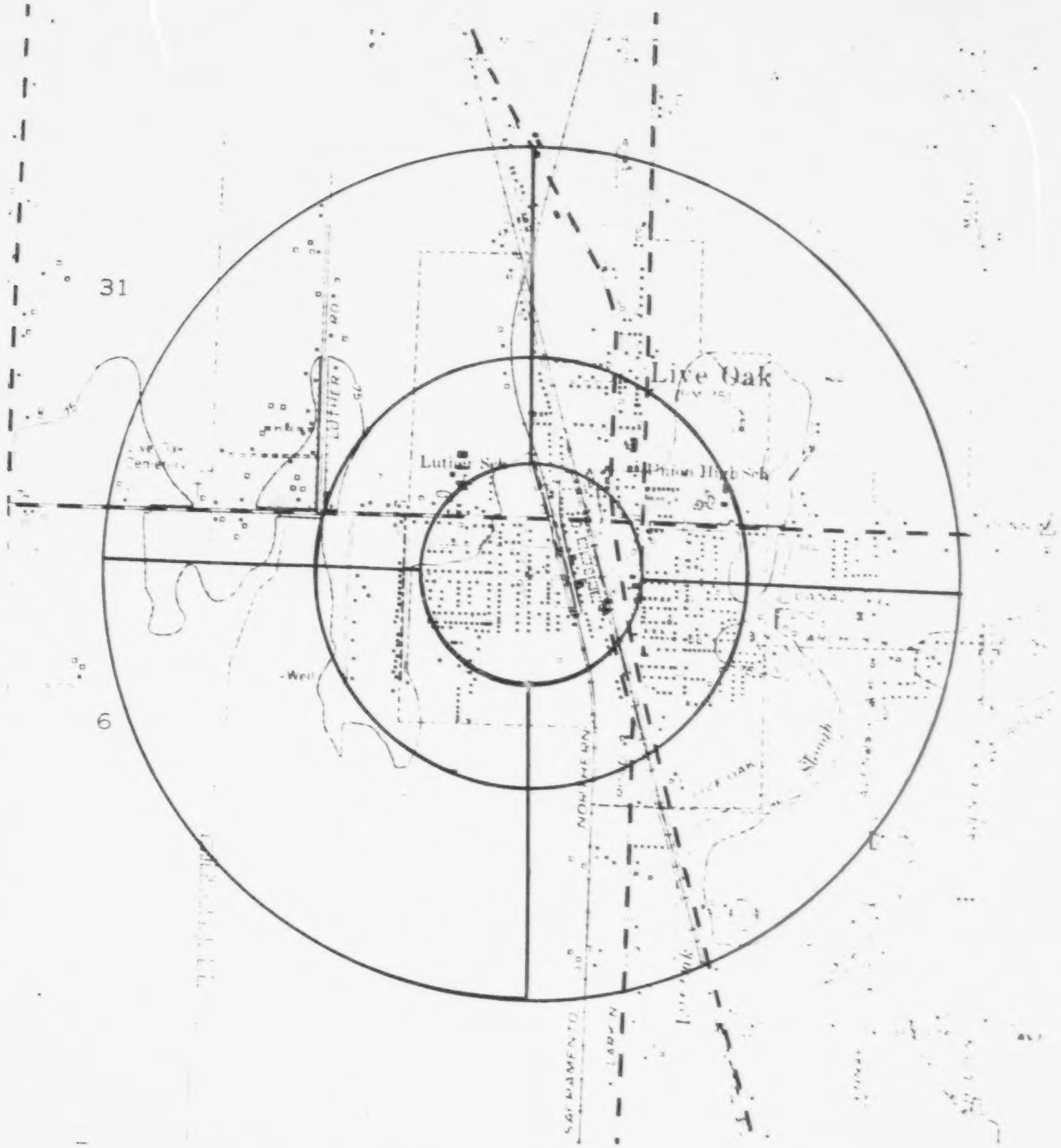
Localized sources, within 200 ft of monitor -

Source	Distance	Description
Fir Street	60 ft	500 ADT, clean, uncurbed
O Street	84 ft	500 ADT, clean, uncurbed

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	82.9	53
1976[a]	110.1	58
1975[a]	76.1	38
1974[a]	79.3	50
1973[a]	60.1	14

[a] May not represent year's average.


31
Live Oak
Luther Sch
Union High Sch
Well
6
NORTHERN
Slough
SACRAMENTO

One mile radius around 2745 Fir Street, Live Oak site.

Viewed to the north-northwest.

Viewed to the east-southeast.

Sampler at 2745 Fir Street, Live Oak.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates	
					x	y
No point sources within 5 mi of site.						

AREA SOURCE SUMMARY

Site: 2745 Fir Street, Live Oak

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.7	0.5	0.5	0.3	0.2	0.2	0.2		0.1	2.7
Comm/Ind fuel		0.3	0.2	0.2	0.1	0.1	0.2	0.1			1.2
Incinerators											
Rail/Air		0.7	0.4	0.4		0.2	0.2	0.2		0.1	2.2
Auto exhaust	1.9×10^7 VMT	1.2	1.5	1.2		0.4	2.7	2.0		1.3	10.3
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards											
Clean streets	1.9×10^7 VMT	10.4	12.5	10.2		3.4	22.8	16.8		11.2	87.3
Comm streets											
Unpaved roads											
Cleared areas	0.5 ac										
Construction											
Agriculture	1106 ac	0.1		0.1	0.3	0.3	2.2	2.1	3.8	2.3	11.2
Storage areas	1 ac		3.1								3.1
Unpaved pkg lots	1.2×10^3 VMT	0.3	0.4	0.1						0.2	1.0

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	2.9	6.2	7.3	16.4
IND PROCESSES				
FUGITIVE DUST	10.8	30.4	61.4	102.6
Total	13.7	36.6	68.7	119.0

DESCRIPTION OF SITE

SAROAD code - 051260001F01

Location - 695 Oleander Street, Chico

UTM coordinates - 599.4, 4398.8

Monitor height - 12 ft, on roof of trailer

Topography - No special terrain

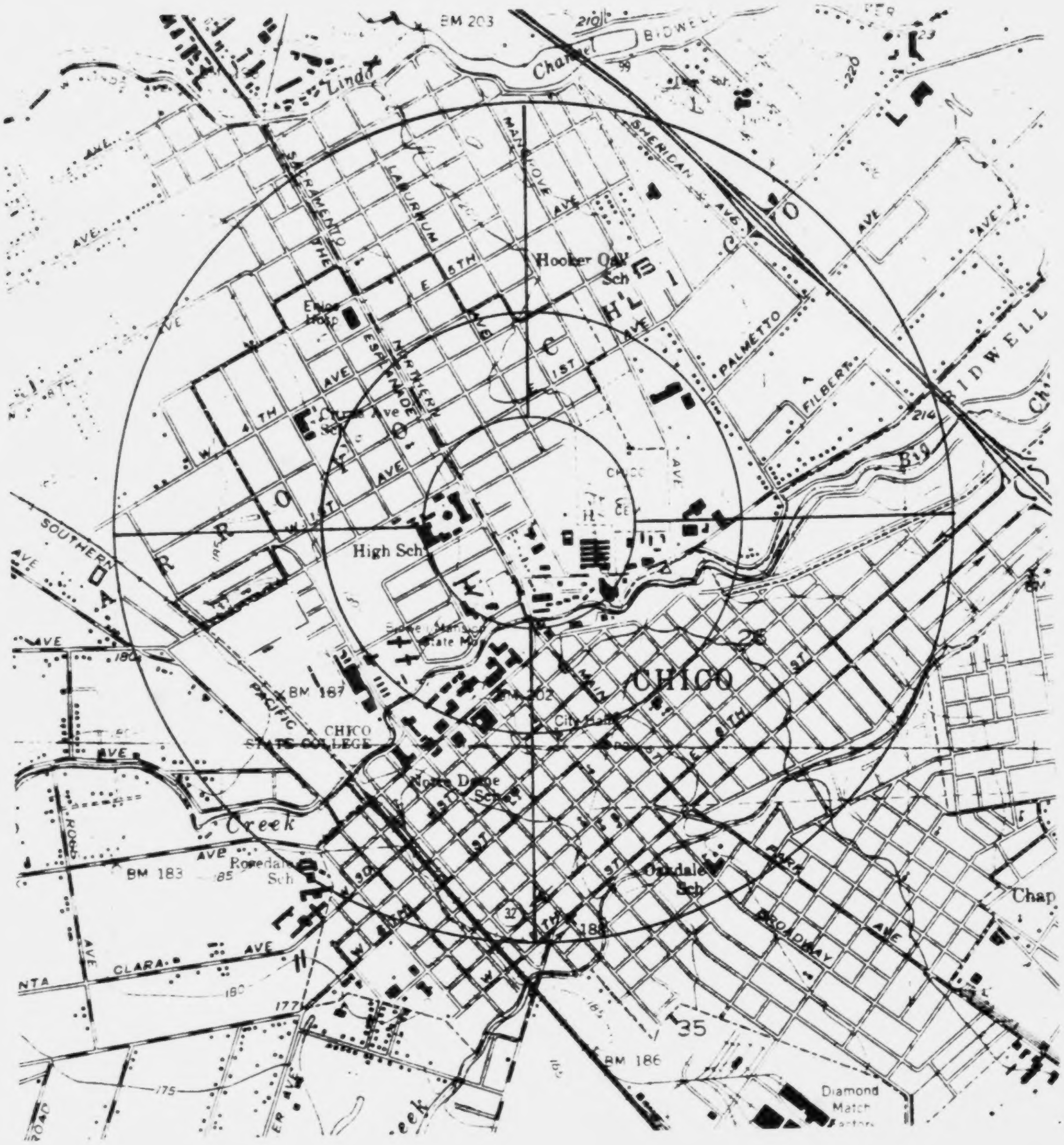
Localized sources, within 200 ft of monitor -

Source	Distance	Description
Oleander Avenue	25 ft	2500 ADT, clean, curbed
Francis Willard Avenue	25 ft	1500 ADT, clean, curbed

Air quality data -

Year	Annual geometric mean, $\mu g/m^3$	No. of samples
1977	66.8	56
1976	80.4	59
1975	69.3	59
1974	77.6	60
1973[a]	77.0	47

[a] May not represent year's average.


BM 203
Lindo
Channel
BIDWELL
SHERIDAN AVE
SACRAMENTO
THE
LABURNUM
MANGROVE AVE
Hooker Oak Sch
5TH
E
Enloe Hosp
ESPLANADE
NORTHERN
1ST
AVE
PALMETTO
FILBERT
BIDWELL
Big
W 4TH
AVE
Citrus Ave Sch
AVE
High Sch
CHICO
SOUTHERN
PACIFIC
Stone Mansion State Mon
BM 187
BM 202
CHICO
City Hall
CHICO STATE COLLEGE
5TH
ST
Notre Dame Sch
Creek
Rosedale Sch
BM 183
CLARA
AVE
Oakdale Sch
PARK
BROADWAY
AVE
Chap
35
BM 186
Diamond Match Factory
ROAD

One mile radius around 695 Oleander Street, Chico site.

Viewed to the south-southwest.

Viewed to the east-southeast.

Sampler at 695 Oleander Street, Chico.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates x	UTM coordinates y
1	Continental Nut	40	1.3	1	598.4	4400.6
2	Diamond International	431	1.6	3	600.2	4396.4
3	Sierra-Pacific Industries	27	3.9	1	597.8	4404.8

AREA SOURCE SUMMARY

Site: 695 Oleander Street, Chico

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.2	0.2	0.3	0.3	0.4	0.5	0.4	0.3	0.5	3.1
Comm/Ind fuel		0.3	0.1		0.3				0.3	0.1	1.1
Incinerators		0.6	0.5	0.5	0.5	0.5	0.8	0.8	0.8	0.8	5.8
Rail/Air									4.3		4.3
Auto exhaust	$5.4x10^7$ VMT	2.4	2.7	2.1	0.1	2.0	7.9	3.9	1.9	6.6	29.6
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards											
Clean streets	$5.4x10^7$ VMT	20.5	22.4	17.5	1.2	16.3	66.0	32.9	16.0	54.8	247.6
Comm streets											
Unpaved roads											
Cleared areas											
Construction	4 ac		9.4								9.4
Agriculture	35 ac									0.4	0.4
Storage areas	1 ac										
Unpaved pkg lots	$4.7x10^3$ VMT					0.8	0.1	0.5	0.6	1.7	3.7

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	3.5	10.5	29.9	43.9
IND PROCESSES				
FUGITIVE DUST	20.5	67.6	173.0	261.1
Total	24.0	78.1	202.9	305.0

DESCRIPTION OF SITE

SAROAD code - 056160001I01

Location - Riverside Drive, Red Bluff

UTM coordinates - 566.4, 4445.9

Monitor height - 15 ft, on roof of building

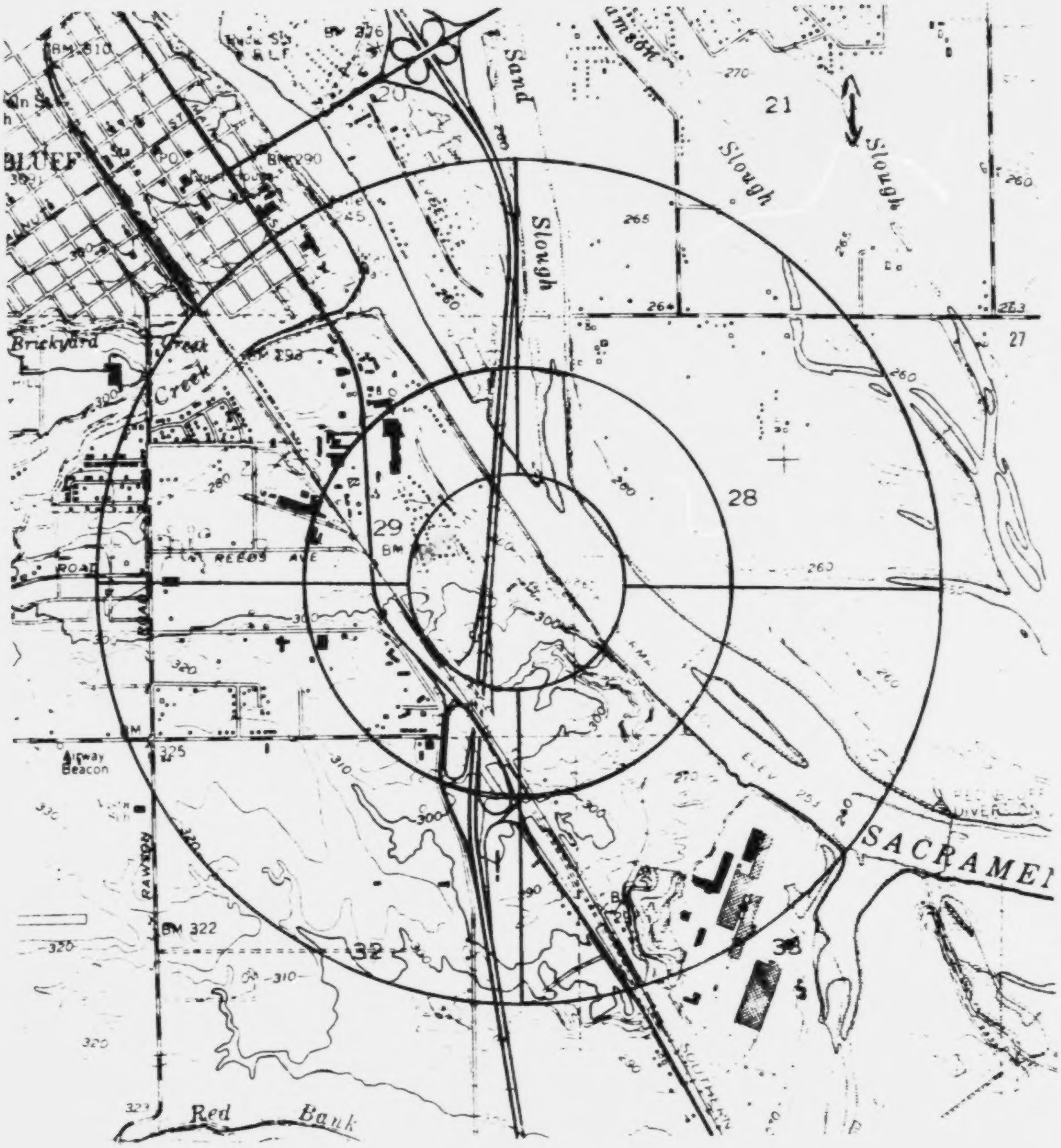
Topography - No special terrain

Localized sources, within 200 ft of monitor -

Source	Distance	Description
Construction	surrounding	3 acres, from March 1978 only

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	61.3	59
1976	67.2	60
1975	55.4	55
1974	53.7	50


BLUFF
Brickyard
Creek
Sand
Slough
Slough
Slough
21
20
27
28
29
32
33
REEDS AVE
ROAD
RAWSON
Airway Beacon
BM 322
BM 290
325
260
265
270
280
300
310
320
330
SACRAMEN
Red
Bank

One mile radius around Riverside Drive, Red Bluff site.

Viewed to the south.

Viewed to the north-northwest.

Sampler at Riverside Drive, Red Bluff.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates x	UTM coordinates y
1	Louisiana-Pacific, Reed Ave.	29	0.55	4	565.6	4446.3
2	Diamond International, Reed Ave.	52	0.59	4	565.5	4446.2
3	Diamond International	234	1.0	3	567.1	4444.5
4	Louisiana-Pacific	73	2.6	3	568.2	4442.2

AREA SOURCE SUMMARY

Site: Riverside Drive, Red Bluff

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.1			0.1	0.3	0.3		0.3	0.6	1.7
Comm/Ind fuel					0.1	0.1		0.9		0.2	1.3
Incinerators					0.1	0.1		1.6		0.1	1.9
Rail/Air					0.5	0.2		1.0		0.5	2.2
Auto exhaust	$1.8\text{x}10^7$ VMT	1.1			1.7	1.8	0.2	0.7	1.7	2.9	10.1
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards											
Clean streets	$1.8\text{x}10^7$ VMT	9.6			13.9	14.8	1.3	5.8	14.3	24.7	84.4
Comm streets											
Unpaved roads											
Cleared areas	2 ac									0.1	0.1
Construction	16 ac								11.7	10.5	22.2
Agriculture	70 ac						1.4				1.4
Storage areas	12.4 ac				0.2				0.3		0.5
Unpaved pkg lots	$1.7\text{x}10^4$ VMT				0.9	0.4			0.9	11.5	13.7

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	1.2	5.0	11.0	17.2
IND PROCESSES				
FUGITIVE DUST	9.6	30.2	82.5	122.3
Total	10.8	35.2	93.5	139.5

CESCRIPTION OF SITE

SAROAD code - 052720001I02

Location - South Main Street, Fort Bragg

UTM coordinates - 430.8, 4365.2

Monitor height - 12 ft, on roof of building

Topography - No special terrain

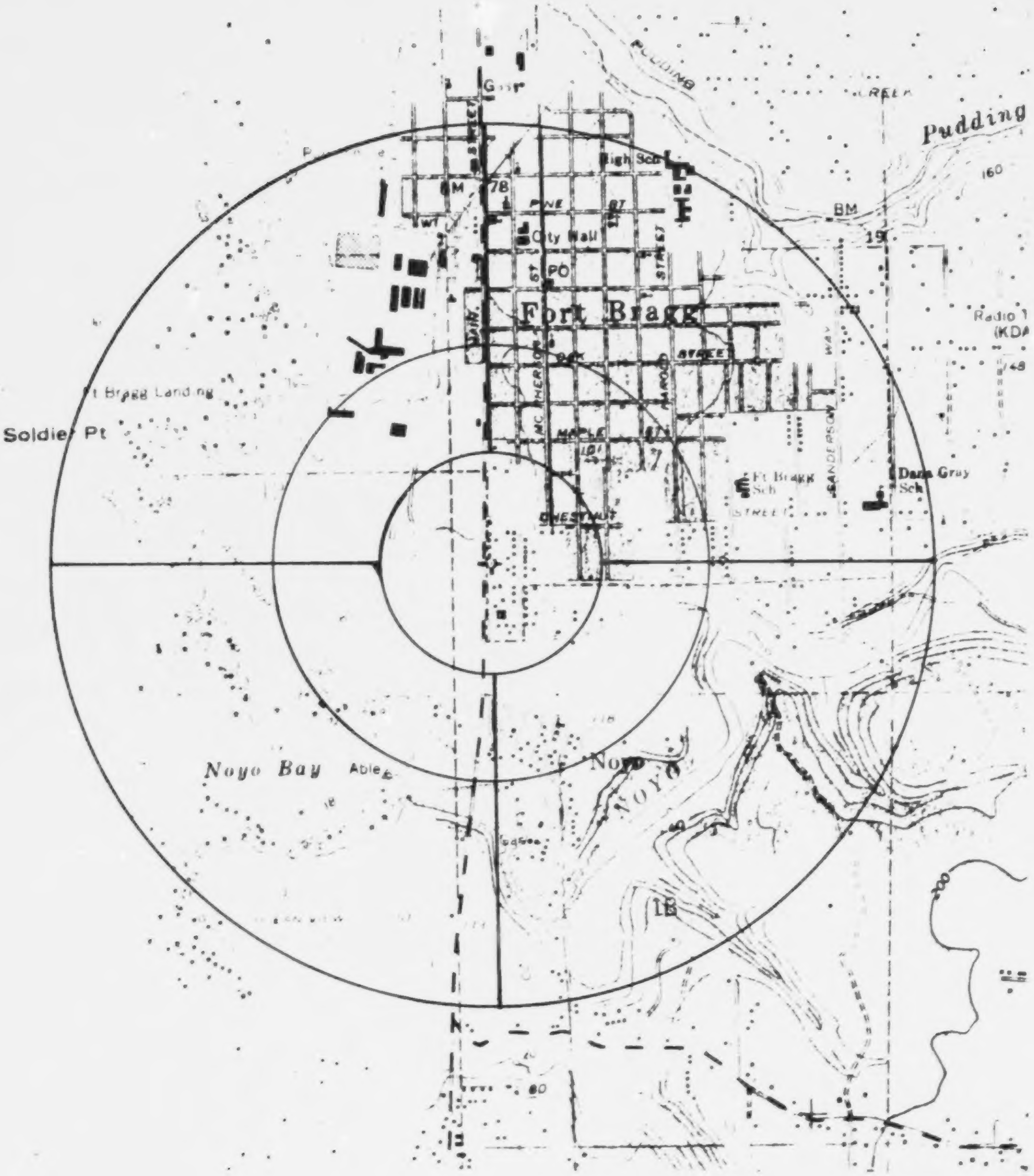
Localized sources, within 200 ft of monitor -

Source	Distance	Description
Main Street	140 ft	17,000 ADT, clean, curbed
Alley	30 ft	50 ADT, clean, uncurbed
Parking lot	10 ft	unpaved
Parking lot	40 ft	unpaved

Air quality data -

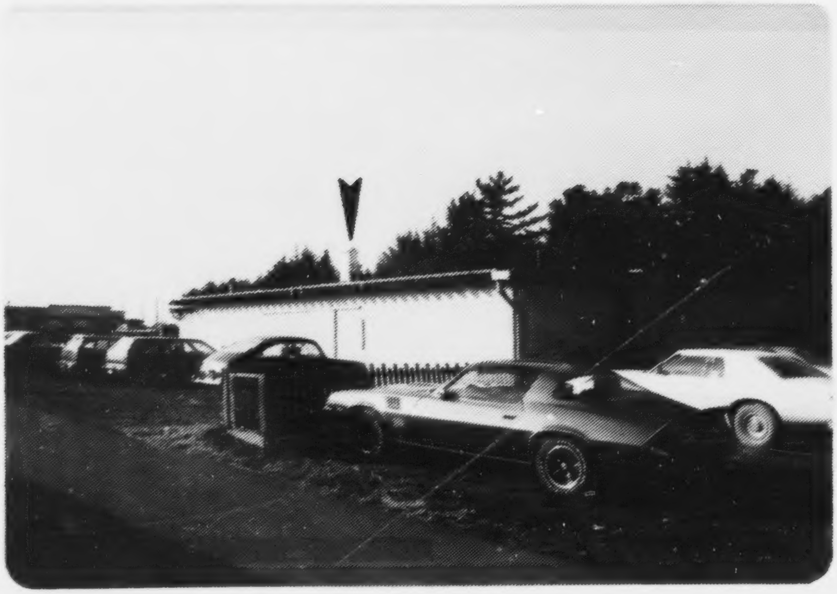
Year	Annual geometric mean, ug/m^3	No. of samples
1977	86.3	53
1976	109.8	53
1975	96.2	49
1974	102.3	55
1973[a]	85.6	32

[a] May not represent year's average.


Pudding
Pudding
Creek
High Sch
City Hall
PO
Fort Bragg
BM
Pine
Street
Maple
Chestnut
Sanderson
Way
Ft Bragg Landing
Soldier Pt
Ft Bragg Sch
Dana Gray Sch
Radio
160
Noyo Bay
Noyo
Noyo
18
60

One mile radius around South Main Street, Fort Bragg site.

Viewed to the northwest.



Viewed to the south-southwest.

Sampler at South Main Street, Fort Bragg.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates x	UTM coordinates y
1	Georgia-Pacific	1673	0.53	1	430.3	4365.9

AREA SOURCE SUMMARY

Site: South Main Street, Fort Bragg

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.5	2.0	0.5			5.0	0.6			8.6
Comm/Ind fuel		0.2	0.1				0.4	0.3		0.4	1.4
Incinerators							1.3	1.0		2.0	4.3
Rail/Air					0.1					1.0	1.1
Auto exhaust	2.0x10^7 VMT	2.4	0.7	0.1	1.0	1.0	2.7	0.4	1.8	1.1	11.2
INDUS PROCESSES:											
Ind processes											
FUGITIVE DUST:											
Railroad yards	10 ac									0.1	0.1
Clean streets	2.0x10^7 VMT	16.7	4.8	1.0	6.0	6.0	19.0	2.6	12.8	7.7	76.6
Comm streets											
Unpaved roads	7.6x10^2 VMT							0.5			0.5
Cleared areas	2 ac										
Construction	4.0 ac			3.7			1.9				5.6
Agriculture											
Storage areas	1.0 ac										
Unpaved pkg lots	2.2x10^4 VMT	1.6	0.3		2.3	1.3	0.2	0.1	0.7	7.5	14.0

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	3.1	5.5	18.0	26.6
IND PROCESSES				
FUGITIVE DUST	18.3	25.4	53.1	96.8
Total	21.4	30.9	71.1	123.4

DESCRIPTION OF SITE

SAROAD code - NA

Location - Park Street, Paso Robles

UTM coordinates - 709.4, 3944.6

Monitor height - 15 ft, on roof of building

Topography - No special terrain

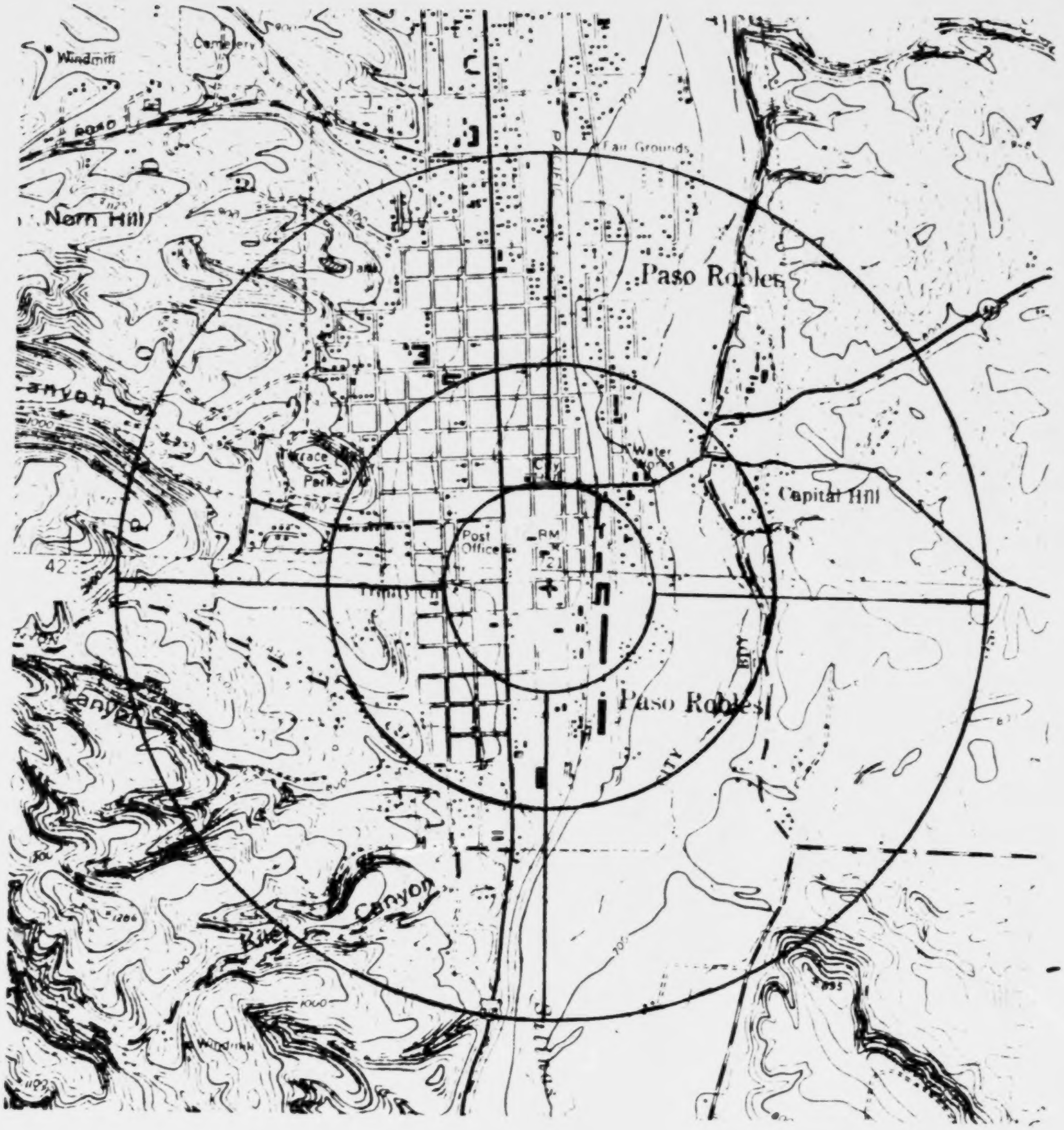
Localized sources, within 200 ft of monitor -

Source	Distance	Description
Park Street	130 ft	500 ADT, clean, curbed
10th Street	40 ft	2300 ADT, clean, curbed

Air quality data -

Year	Annual geometric mean, ug/m^3	No. of samples
1977	72.1	59
1976	70.8	56
1975[a]	64.1	57
1974[a]	76.3	8

[a] May not represent year's average.


Windmill
Cemetery
North Hill
Fair Grounds
Paso Robles
Canyon
Terrace Park
Water Works
Capital Hill
Post Office
BM
Paso Robles
Canyon
Canyon
Windmill

One mile radius around Park Street, Paso Robles site.

Viewed to the east.

Sampler at Park Street, Paso Robles.

POINT SOURCE SUMMARY

Plant ID number	Plant name	Emission level, ton/yr	Distance from site, mi	Wind quadrant	UTM coordinates x	UTM coordinates y
1	Paso Constructors/Pioneer Transit Mix	132	3.2	3	708.9	3939.5

AREA SOURCE SUMMARY

Site: Park Street, Paso Robles

Source category	Activity rate	Emissions by sector, ton/yr									
		1	2	3	4	5	6	7	8	9	Total
COMBUSTION:											
Residential fuel		0.2	0.1		0.1	0.2	0.1		0.1	0.2	1.0
Comm/Ind fuel		0.2	0.1								0.3
Incinerators											
Rail/Air		0.4	0.2	0.3			0.3		0.2		1.4
Auto exhaust	2.7×10^7 VMT	3.2	1.9	1.0	0.5	1.2	2.7	0.8	2.2	1.2	14.7
INDUS PROCESSES:											
Ind processes		1.0									1.0
FUGITIVE DUST:											
Railroad yards											
Clean streets	2.7×10^7 VMT	28.6	17.1	9.4	4.8	11.3	24.6	7.1	19.5	10.6	133.0
Comm streets											
Unpaved roads	1.7×10^3 VMT	2.9									2.9
Cleared areas	11.4 ac	0.2	0.1	0.2			0.6			0.3	1.4
Construction	0.5 ac									2.2	2.2
Agriculture											
Storage areas	0.5 ac		0.1								0.1
Unpaved pkg lots	2.6×10^3 VMT	1.5	0.1		0.3		0.4				2.3

Recap	Emissions by sector, t/yr			
	1	2-5	6-9	Total
COMBUSTION	4.0	5.6	7.8	17.4
IND PROCESSES	1.0			1.0
FUGITIVE DUST	33.2	43.4	65.3	141.9
Total	38.2	49.0	73.1	160.3

APPENDIX G

DEVELOPMENT OF EMISSION FACTORS

Rather than attempt to show how emission factors for all sites were computed, Sacramento was selected as the example site. Emission factors for all other sites were determined through the same process.

RAILROAD YARDS

Most of the emissions in train yards appear to be from wind erosion rather than from train movement. Therefore, an adaptation of the U.S. Department of Agriculture's wind erosion equation is used as the basis for deriving emission factors for railroad yards. The modified equation estimates annual suspended particulate emissions due to wind erosion from exposed soil surfaces:[1]

$$E = a\ I\ K\ C\ L'\ V' \qquad \text{(Eq. 1)}$$

where E = emission factor, tons/ac/yr

a = portion of total wind erosion losses that would be measured as suspended particulate, estimated to be 0.025

I = soil erodibility, tons/ac/yr

K = surface roughness factor

C = climatic factor

L' = unsheltered field width factor

V' = vegetative cover factor

In this equation, K, C, L', and V' are all dimensionless. An average erodiblity (I) of 86 tons/ac/yr is assumed to be applicable for the soil in the railroad yards. The area around railroad yards generally has a fairly smooth surface that is equivalent to a K value of 1.0. The climatic factor for the

Sacramento area is 0.05. An average width of 1000 ft is assumed for railroad yards because this is not a critical variable in the equation. The L' value equivalent to L = 1000 ft is determined from a nomograph in which soil type is also a variable, 0.86. There is no vegetation in rail yards, so V = 0 and V' = 1.0. Also, these areas are generally treated with oil or chemicals to reduce dust and weed problems. Therefore, the emissions are estimated with the above values and the following assumptions:

- Sandy soil (I = 86).
- No vegetation.
- Half the area is stabilized, with an emission rate of 20 percent of the unstabilized area.
- Train traffic increases the wind erosion emissions by 20 percent.

The resulting emission factor is:

$$E = (0.025)(86)(1.0)(0.05)(0.86)(1.0)\left(\frac{1 + 0.2}{2}\right)(1.2)$$

$$= 0.07 \text{ ton/ac/yr}$$

REENTRAINED DUST FROM PAVED STREETS

The most recent emission factors for estimating emissions from paved streets are obtained from a draft of AP-42.[2] The recommended emission factors are 5.0 g/VMT for clean streets and 21.3 g/VMT for commercial streets. These factors do not include an exhaust emission factor and are not corrected for days with rain.

Historical rainfall data for Sacramento indicate a mean of 57 days with at least 0.01 inch of rain.[3] Based on this information, the reentrained dust emission factors are reduced by approximately 16 percent.

Based on national estimates for the percentage of heavy duty gasoline and diesel trucks and interpolating from 1975 and 1980 California emission factors, an exhaust emission factor of 0.49 g/VMT for clean streets and 0.98 g/VMT for commercial streets is calculated from published emission factor data.[2] This factor is added to the reentrained dust factor to get the total emission factors for paved streets: 4.69 g/VMT for clean streets and 18.98 g/VMT for commerical streets.

UNPAVED ROADS, ALLEYS, AND LOTS

Many different groups have investigated emissions from unpaved roads. All the studies show emission rates usually in the range of 1 to 20 lb/VMT, and show that the rate is highly dependent on vehicle speed. After reviewing these studies, EPA selected the following emission factor for publication in AP-42:[2]

$$E = (0.6)(0.81)(s)(S/30)\left(\frac{365 - w}{365}\right) \qquad \text{(Eq. 2)}$$

where E = emission factor, lb/VMT

0.6 = fraction of total particulate less than 30 μ diameter

s = percent silt of road surface material

S = average vehicle speed, mph

w = mean annual number of days with 0.01 inch or more of rainfall

The percent silt on gravel road surfaces is about 12 percent based on data presented in the EPA publication, Development of Emission Factors for Fugitive Dust Sources.[1] For graded and drained road surfaces, no aggregate material is applied to the roadbed so it is composed of compacted native soil. The fine material originally on the surface is probably rapidly removed by turbulence from passing vehicles or by wind and water erosion forces. The remaining stable surface is composed of sand and pebble-sized particles, with dust being generated primarily by the continuing mechanical breakdown of these particles as a result of traffic. It is assumed that the percent of silt-sized particles on a seasoned dirt road surface is approximately the same as that for gravel, or 12 percent. The mean number of days with 0.01 inch or more of rainfall is 57. For various vehicle speeds, the following emission factors result:*

10 mph	1.6 lb/VMT
20 mph	3.3 lb/VMT
30 mph	4.9 lb/VMT
40 mph	6.6 lb/VMT

Because there are no data published on emissions from unpaved lots and alleys, it is assumed that the factor for unpaved roads with traffic speeds of 10 mph is applicable for these sources.

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* Different speeds were estimated for individual road sections.

CLEARED OR EXPOSED AREAS

The modified wind erosion equation described earlier is used for estimating emissions from cleared or exposed areas. An average erodibility (I) of 79 tons/ac/yr is assumed for the soil types common to this area. The cleared areas are generally left with a fairly smooth surface that is equivalent to a K value of 1.0. The climatic factor for the Sacramento area is 0.05. An average field width of 1000 ft is assumed for all the cleared areas because this is not a critical variable in the equation. The L' value equivalent to L = 1000 ft is determined from a nomograph in which soil type is also a variable, 0.81. There is no vegetation on cleared areas, so V = 0 and V' = 1.0.

Based on these input data, the average emission rate from cleared areas is 0.08 ton/ac/yr.

CONSTRUCTION

The emission factor presented in AP-42 of 1.2 tons/ac/mo is corrected for the climatic conditions in Sacramento by use of the equation:[2]

$$E = \frac{1.2}{(PE/50)^2} \qquad \text{(Eq. 3)}$$

where PE = 64 for Sacramento
E = 0.73 ton/ac/mo

This value is appropriate for residential and commercial construction with excavation and regrading, and includes the effect on emission reduction of moderate watering of the site. Most construction projects are assumed to be fugitive dust sources for only three or four months a year.

AGRICULTURE

Total emissions from agriculture are calculated from the sum of tilling and wind erosion emissions. The factor for tilling from AP-42 is:[2]

$$E = (0.8)(1.4)s/(PE/50)^2 \qquad \text{(Eq. 4)}$$

where E = emission factor, lb/ac/run

0.8 = fraction of total particulate less than 30 μ diameter

s = percent silt in surface soil

PE = precipitation-evaporation index

An average of three tilling operations per year is assumed, and a silt content of 36 percent. Therefore, total tilling losses are 0.04 ton/ac/yr. Exceptions to this emission factor are orchards and vineyards, where tilling losses are assumed to be controlled 50 percent because most farmers till the ground while it is as moist as possible (e.g., after watering or during the rainy season).[4] This is done because large amounts of dust on trees or vines can encourage infestation by insects.

The modified wind erosion equation described earlier is used for determining the wind erosion component of agricultural emissions. All variables in the equation except C are dependent on either soil type or crop grown on each field. No emission factor data could be found concerning windblown dust from orchards and vineyards. Values used in the wind erosion equation for these categories are determined in the following manner.

To use the wind erosion equation for orchards and vineyards, the variables K, V, and L need to be determined. Because vineyards are planted north-south for optimum sun exposure and because the prevailing wind in both valleys has a north-south orientation, furrowing in vineyards does not control windblown dust. Therefore, K is assigned a value of 1.0. Orchards would have the same K value as vineyards because the ground around the trees is generally smoothed. Again, due to north-south planting of vineyards, L essentially becomes infinite as the prevailing winds are unobstructed by vegetation or natural breaks. The same is true of orchards they because are planted square and not in rows. To better suit the conditions of the sites studied in this analysis, however, an L value of 2000 ft is assumed for orchards and vineyards.

Falling leaves supply the major portion of vegetative cover in orchards and vineyards during the nonactive season. Although many of them blow away, some remain to provide ground cover, especially if they are tilled into the top soil. Considering a yield of about 5 to 10 pounds of leaves per tree and 200 trees per acre, the range of V would be 1000 to 2000 lb/ac. It is determined that 1000 lb/ac best represents V for both orchards and vineyards.[4] The following average values are assumed for the Sacramento area:

$$I = 79$$

$$C = 0.05$$

Crop	K	L	L'	V	V'	E, tons/ac/yr
Vineyards	1.0	2000	0.93	1000	0.03	0.003
Orchards	1.0	2000	0.93	1000	0.03	0.003
Cotton	0.5	3000	0.87	250	0.60	0.02
Corn	0.6	2000	0.82	500	0.11	0.005
Wheat	0.6	2000	0.82	1350	0.01	0.0005
Beans	0.5	1000	0.65	250	0.58	0.02
Bare[a]	1.0	1000	0.82	100	0.83	0.07

[a] Fields that have had all vegetative stubble removed and the surface smoothed before the nonactive season.

Therefore, the combined agricultural losses are as follows:

Vineyards - 0.04 ton/ac/yr
Orchards - 0.04 ton/ac/yr
Cotton - 0.06 ton/ac/yr
Corn - 0.04 ton/ac/yr
Wheat - 0.04 ton/ac/yr
Beans - 0.06 ton/ac/yr
Bare - 0.11 ton/ac/yr

AGGREGATE STORAGE AREAS

The emission factor for this source category was based on sampling performed in the Kansas City and Cincinnati areas. The emission factor (E) is:[1]

$$E = \frac{13.2}{(PE/100)^2} \qquad \text{(Eq. 5)}$$

where PE = 64 for Sacramento

E = emission factor, lb/ac/day

The annual emission factor for aggregate storage is 5.9 tons/ac/yr.

UNPAVED STORAGE AREAS

No factor was found for this source category. By comparison with other source categories, it is estimated that annual emissions per acre from this source are greater than for a cleared area (0.08 ton/ac/yr) or railroad yards (0.07), but not nearly as high as aggregate storage (5.9) or construction (0.73). A value of 0.10 ton/ac/year is used for this minor source category.

CORRALS

An emission factor of 3 tons/ac/yr is taken from a previous PEDCo study for this source category.[5]

GRAIN ELEVATORS

A value of 1.8 tons/silo/yr was developed from file data for a previous PEDCo study of particulate air quality in rural Kansas and Nebraska.[6] This value is applied to California sources for which NEDS data are not available.

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